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The research hypothesis being tested is that a telemammography system utilizing a laser film digitizer at the transmitting site (with a 50-micron pixel size for spatial resolution and a 12-bit pixel range for contrast) and interactive two grayscale display monitors (2048 x 2560 x 8/12 bits) at the receiving site can be used to interpret mammography images with an accuracy level sufficient for primary diagnosis. To test the research hypothesis, the following four aims are to be completed: (1) Collection of 200 normal cases and 200 abnormal cases of specifically selected analog mammographic film images and patient data for use in evaluating a telemammography system; (2) convert the collected database of analog mammographic films into digital arrays using a laser film digitizer with a 50-micron pixel spot size and 12 bits per pix of dynamic range; (3) conduct an ROC analysis of the retrospective database of the analog mammographic image and digitized arrays displayed on the two monitor interactive gray scale workstation, each monitor displaying 2048 x 2560 x 8/12 bit portions of the 4K x 4K digitals arrays; (4) implement a digital transmission for evaluation of the telemammography system; (5) implement and test a quality control progra and (6) evaluate the throughput rate of the implemented telemammography system.

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1. INTRODUCTION

1.1 Nature of the Problem

Current estimates, excluding cancers of the skin, identify breast cancer as the most commonly diagnosed malignancy among women in the United States.

Telemammography offers the potential to provide improvements in efficiency and effectiveness over the current mail-service protocol using traditional film-screen mammography imaging. The sources of digital mammography can be either digitized analog film-screen examinations (50 micron spot size) of a full breast digital mammography unit (40 micron spot size, 4k x 6 k x 2 Bytes/pixel). It is likely to be three years before full breast digital mammography units will become widely available. The three significant technology blockages to the use of full breast digital systems in telemammography are the following: (a.) the transmission of large size records (4k x 6 k x 2 Bytes/ 48 Mbytes/image; 8 images for a total file of 384 Mbytes per screened examinations); (b.) the grayscale display of 8 images, each 48 Mbytes wide; and (c.) the archiving strategy of these large image files.

(1). Full breast digital imaging technology promises removal of the limitations of conventional mammography, due in part to the detectors (limited latitude and contrast, lack of detection efficiency, and film granularity noise) . 2.) Two significant parameters of digital mammography systems are the spatial resolution. Using screen film mammography, with a field of view of 18 x 24 cm or 24 x 30 cm, the limiting resolution is about 20 line pairs per millimeter (lp/mm).

This would require a spot size of 25 microns, implying a matrix size of 9k x 12k and a 2

Byte per pixel dynamic range. Due to the efforts of scattering, and an attenuation factor between 7.5 to 75, the digital array size is 4k x 6k x 2 Bytes per pixel. Jaffe and co-workers (2) use the following detector design characteristics: (a.) efficient absorption of the radiation beam; (b.) linear response over a wide range of radiation intensity; (c.) low noise; (d.) spatial resolution of approximately 10 line pairs per millimeter (less than a 50 micron sampling), (e.) a field of view of 18 x 24-cm; and (4.) acceptable heat loading of the x-ray tube.

Prototype full breast digital mammography units are being evaluated at selected sites. We are evaluating the Bennett Contour mammography machine. This digital mammography unit had the following imaging parameters 19 cm x 25 cm imaging area; (b.) 13 line pairs/mm spatial resolution; (c.) 604 k x 4.8 k digital array; (d.) single exposure; 21 fiber optics coupled; (f) 14 bit dynamic range per pixel; (g.) image acquisition rate of 10 seconds; (h.) quantum noise limited; (I.) computer is Sun Sparcstation 20; (j.) networking protocol is TCP/IP; and (k.) software is combination of UNIX, X-Windows, and MOTIF-GUI.

The computer system is based upon a common standard bus (SCSI, S-bus, and VME-bus). More than 100 images, each 48 Mbytes, can be stored on a single disc. The software is built around the X-Window/MOTIF graphical user interface. This system is being evaluated so that the full potential of digital mammography can be determined for the early detection and management of breast cancer.

1.2 Purpose of the Present Work

The research hypothesis being tested is that a telemammography system can interpret mammography images with an accuracy level sufficient for primary diagnosis utilizing a film digitizer at the transmitting site (with a 50-micron pixel size for spatial resolution and 12 bit pixel range for contrast) and interactive grayscale display monitors (2448 x 2560 x 8/12 bits) at the receiving site. The full breast digital mammography (FBDM) units generate a 4k x 6k x 2 byte digital array for each image. It is very difficult to design display protocols for FBDM systems.

A successful telemammography system will provide benefits in the following areas:

A. PRIMARY DIAGNOSIS. Telemammography offers the ability to provide mammographic consultations to undeserved and remote areas. Achieving the image quality required of a telemammography system for primary diagnosis will enable an outreach program to enhance a region's breast screening programs and to improve patient care. Expert mammographic interpretation meeting requirements established by the Mammography Quality Standards Act can be monitored to localities lacking such expertise.

B. INTEGRATION OF MAMMOGRAPHY GROUP PRACTICE DISTRIBUTED OVER MULTIPLE IMAGING CENTERS. As the awareness regarding the role of mammography in early detection of breast cancer increases, so does the need for more accessibility to low cost screening mammography. More and more practices are responding to the the rapidly growing utilization of mammography by opening out patient clinics to imaging practices. Telemammography

would enable a group with a limited number of expert mammographers to handle multiple off-site practices. Additionally, if appropriate for the practice, the radiologist could supervise screening mammograms off-site and determine the need for any additional views at the time of examination instead of having the patient return at a later time. Image quality could also be supervised off-site via telemammography. Another advantage of this system is that, due to inefficiencies of scale, mammography costs would be lower and a lower fee for interpretation could be maintained without the need for an on-site radiologist. In part, this would be related to alleviating the need for the physician to travel to and from the various satellite screening sites.

C. OVER READING OF MAMMOGRAPHY ISSUES. There is increasing emphasis on the interpretive skills of radiologist's reading mammograms as part of the quality assurance process monitored both by the ACR Mammography Accreditation program and by the Food and Drug Administration. Residency programs are offering more time in mammography rotations now compared with only a few years ago; there have been formal standardized training programs for radiology residents and mammographic technologists through the ACR-CDC Cooperative Agreement. Nonetheless, the impact of the accreditation guidelines and the training programs will not be immediate, and there remains a need for expert mammographic interpretation in many practices. With telemammography, a small number of expert mammmographers could provide consultation services or second readings of mammograms for a larger number of general radiologists, and improve the quality of care. Additionally, the data and images for patients in a region could be stored and utilized for the development of a regional

mammography database.

D. IMPROVED CONSULTATION WITH SURGEON. Primary care physicians and surgeons could review the mammograms on their patients without the need for "signing out" the original films. On a broader scale, the utilization of telemammography at multiple radiology practices in a referral region could provide greatly improved access to a patients' prior examination, regardless of where the patient obtained subsequent mammograms. The importance of such transmission would be multifocal: original films would not need to be mailed, risking their loss, the cost of making copy films could be avoided: and the facility interpreting the current study would have a much more rapid access to the prior exams, thereby, improving the accuracy of diagnosis expediting the diagnostic evaluation of any new abnormalities, limiting the need for more costly diagnostic consults of unchanged findings and diminishing the anxiety of the patient who is waiting for her final results.

2. METHODS OF APPROACH

2.1 Proposed Tasks

Three tasks are required in support of evaluating the research hypothesis.

Task 1. A selected set of analog mammographic films have been collected and digitized using a laser film digitizer set at 50-micron spot size and a 12 bit dynamic range.

An ROC analysis has been conducted on the analog mammographic films and the digitized films are to be displayed on grayscale monitors (2048 x 2560 x 8/12 bits).

Task 2. A digital communication network will be implemented between the Department of Radiology Breast Imaging Center in the Diagnostic Center for Women (Primary Care Center Building, UVA) and the off-campus outpatient Virginia Mammography Center (Northridge facility, UVA, 8 miles from the campus). A laser film digitizer,(50-micron spot size, Model 150, Lumisys Inc., Sunnyvale, CA) and computer workstation (SUN, SPARC Model 40) will be installed at Northridge. Transmission of the digitized mammographic films will be over a T-1 carrier (1.544 Mbits/sec signaling speed..) to the department's PACS and displayed on 2048 x 2560 x 8/12 bit grayscale monitors. A protocol for end-to-end telemammographic quality control will be implemented.

Task 3. A performance evaluation will be conducted of the teleradiology system using the metrics of response time, throughput,, reliability, and clinical acceptance.

We divided the above three tasks into the following aims:

Aim 1. Collection of an adequate retrospective database of analog mammographic film images and patient data for use in evaluating a telemammography system.

Aim 2. Convert the collected database of analog mammographic films into digital arrays using a laser film digitizer with a 50-micron pixel spot size and 12 bits per pixel of dynamic range.

Aim 3. Conduct an ROC analysis of the retrospective database of the analog mammographic images and the digitized arrays displayed on the 2048 x 2560x 8/12 bit grayscale monitors.

Aim 4. Implement a digital transmission service between the Virginia Mammography Center at Northridge and the PACS in the University of Virginia Department of Radiology and its workstations including that in Diagnostic Center for Women.

Aim 5. Design, implement, and evaluate an end-to-end quality control program for the telemammography system.

Aim 6. A performance evaluation will be conducted of the telemammography system using the metrics of response time, throughput, reliability, and clinical acceptance.

2.2 Experimental Methods and Results

2.1 Statement of Work.

The proposed statement of work for the contract was identified by the year and aim as follows. We present these tasks and aims, commenting on our current progress at the completion of the second year of the contract.

Year 1.

TASK 1: Aim 1 COMPLETED IN YEAR 1

- Complete collection of 200 normal and 200 biopsy-proven malignant analog mammographic films to form an image database (6 months to complete).
- Collect pathology and consultation reports for the 400 images in the database.
- Conduct an image quality control protocol on the image database to insure correct ground truth identification, correct diagnosis, and an adequate optical density range in each image.
- Conduct a review of the identified Regions if Interest (ROIs) to insure proper I identification.

During year 1, we completed the collection of 200 normal and 200 abnormal analog mammographic films to form our image database (see Appendix analog mammographic films to for a listing coded by case number). Abnormal cases include benign and malignant lesions, with pathology serving as ground truth. We have completed the collection of patient data and have added the patient's age as well as demographic data. We conducted an image quality control protocol on the analog image database to insure proper ground truth identification, correct diagnosis, and the proper optical density range in each image. All cases were reviewed and lesions were analyzed and classified by using ACR lexicon, The abnormal cases were also verified for presence of only one lesion. The abnormals selected reflected a range of difficulty in lesion perception and analysis.

Normal mammograms were selected as normal based in the following: (1.) Initial consultation reading was normal; (2.) review of images showed no significant abnormality; and (3.) follow up mammogram at least 24 months later showed no interval change.

Mammographic findings of intramammary lymph nodes, classically benign calcification of fat necrosis, dermal calcifications and vascular calcification are considered pathognomically benign and could be present on "normal" cases.

Parenchymal density for each case was classified on a scale of 1 to 4 based on the ACR lesion (1 = fatty; 2 = scattered fibroglandular tissue; 3 = heterogenously dense; and 4 = extremely dense). The perendynal density of normal cases was matched to abnormals. There were an approximately equal number of fatty normals, fatty abnormals, etc.

The image database was initially collected together with an overlay sheet of clear plastic identifying the Regions of Interest (ROI's) to insure proper identification. Our intent was to digitize this ROI and use it for display on the grayscale workstations. We recognizes a bias in the reader response because of the use of ROI'S. That is, if only a 1k x 1k ROI is displayed to each reader, a bias is introduced by not displaying the full image.

TASK 1: Aim 2

- Digitized the 400 analog mammographic images with a 50 micron pixel spot size and 12 bits per pixel of dynamic range.
- Conducted a review of the digitized images using the grayscale display

workstations (2048 x 2560 x 8/12 bits) in the PACS network.

Each of the film-screen analog images were digitized to 50 micorn spot size using a Lymis Model 150 Laser film digitizer (4k x 4k x 12 bits). Then, they were archived onto 4 mm digital archiving data tape. All 400 mammography examiniations are archived into a tape library. The digitzed film screen library is in two portions. The images are archived with the database having pointers to the images and the BIRAD data.

TASK 1: Aim 2

- Complete digitization of the collection of the analog mammographic films (two months of year 2, began in year 1).

THIS TASK HAS BEEN COMPLETED IN YEAR 2

TASK 1: Aim 3

Complete ROC analysis of mammography analog films (requires two months of year 2 to complete task began in the first year)..

THIS TASK HAS BEEN COMPLETED IN YEAR 2.

The 400 cases of analog image were interpreted by elder readers at the University of Virginia and the Medical College of Virginia. The number of readers was expanded from six to eleven. Normal and abnormal cases were randomized out the films were read in rounds of 50 at each sitting.

Image interpretation was conducted with the following gradings system:

Masses 1. (definitely not present); 2. (probably not present); 3. (equivocal); 4. (probably present; 5. (definitely present).

Microcalcifications 1. (definitely not present); 2. (probably not present); 3. (equivocal) 4. (probably present); 5. (definitely present).

Dilated lactiferous ducts 1. ; 2; 3; 4; 5;.

Focal areas of asymmetry or architectural distortion 1; 2; 3; 4; 5.

Diagnosis of image 1. (definitely benign); 2 (probably benign); 3. (equivocal); 4. (probably malignant) 5. (definitely malignant).

We have completed the ROC analysis of the readers, (appendice II)

In year two we have also completed the coding of all cases according to the ACR lesion with description and pathologic classification. The information has been collected in the ACR BIRAD Program Database (appendice III).

Year 2.

For the year 2 the following Tasks and Aims were to be accomplished.

TASK 1: Aim 3

- Utilize the collected digitized image data set to perform an ROC curve analysis (requires six months) utilizing the 2048 x 2560 x 8/12 bit grayscale display stations in the University of Virginia PACS by six readers.

DUE TO THE TECHNICAL DIFFICULTIES WITH THE GRAYSCALE DISPLAY MONITORS, THIS TASK IS TO BE COMPLETED IN YEAR 3.

- TASK 2: Aim 4
- Implement the T-1 connection between Northridge facility and the University of Virginia PACS (three months of the Year 2).

Test network for end-to-end fidelity.

The T-1 connection between Northridge facility and the University of Virginia PACS was to be installed a no cost to the contract. This effort has been delayed to year 3 for the following reasons:

1. The UVA PACS high resolution display stations are 2k x 2.5k with frame buffers that are 16 Mbytes wide. However, the boundary of all acceptable images to be displayed has been set to 22k x 2.5k, thereby making it impossible to place 4k x 4k digitized film-screen mammograms into the frame buffer. We have asked E-SYSTEMS to modify the software but thus far they have not made the necessary changes so we can display the 50 micron digitized mammograms.

2. By digitizing the film-screen mammograms at 70 micron spot size and then thresholding the images (removing the non-breast tissue portion of the image), they are reduced to 2k x 2.5k. However,, such a reduction prohibits the comparison of an analog film-screen ROC analysis to image that of a 70 micron spot size image.

3. A four monitor grayscale display system is being developed by the investigators to enable the grayscale display of 4k x 4k images. This portion of the study will be delayed and conducted during year 3 of the study.

4. An ATM connection is being installed from the MCV Stoney Point Mammography office to MCV Nelson Clinic for transmitting digitzed screen-film mammograms. Another testbed will be a second MCV satellite mamamography office in Blauster, VA, a rural site approximately 70 miles from Richmond.

TASK 2: Aim 5

- Design , establish, and test an end-to-end quality control program for validating a telemammography system.
- Operate the telemammography system to collect data for evaluating the quality control program.

We have designed and validated an end-to-end quality control program using phantoms. The data has been collected intra-testbed in year 2. In year 3 we plan to conduct the test using an inter-site protocol. The first test will utilize the ACTS satellite and will begin in November 1996.

For years 3 and 4 the following Tasks and Aims are to be accomplished.

YEAR 3

TASK 1: Aim 3

- Complete the ROC analysis of digitized mammographic images displayed on 2048 x 2560 x 8/12 bit grayscale display stations in the University of Virginia PACS.

TASK 2: Aim 5

- Implement the end-to-end quality control program for evaluation and analysis.

TASK 3: Aim 6

- Implement a software data logger program which will record events on the telemammography system.
- Implement the performance evaluation using the metrics of response time, throughput, reliability and clinical acceptance.

3: THE PROBLEM OF DISPLAYING FULL BREAST DIGITAL MAMMOGRAPHY EXAMINATIONS

It is well known that breast cancer is the most common form of cancer in American women. It is the second leading cause of cancer related deaths among women only surpassed by lung cancer. The promising increase in the rate of detected breast cancer is believed to be partly due to improved screening through mammography examinations (4). Currently, almost all mammography is performed using screen film systems and x-ray units dedicated to performing mammography examinations. There are, however, several limitations in the use of screen-film systems for mammography. Screen-film mammography is limited in detecting cancers in patients with radiodense breast tissue (8). These women make up about 40% of the general population (9). Digital mammography reduces the limitations of conventional screen-film imaging which are due to the detector (restricted latitude and contrast, lack of detection efficiency, and to the impact of film-granularity noise) and to the image acquisition (inefficiency of scatter rejection) (10). Considerable experience with digital mammography systems has been obtained from several hundred small field, spot image units that have been installed. The units acquire small-field, spot images during needle localization or core biopsy procedures. These units have demonstrated the following advantages: (a) shorter procedure times; (b) improved image quality provided by the large pixel dynamic range and wide linear latitude of the CCD technology; (c) lower overall dose; (d) reduced scattering which improves image quality; (d) separation of the x-ray imaging system and the grayscale display; and (e) the ability to acquire, transmit, and digitally archive the images.

The clinical acceptance and use of full-breast digital mammography systems now depends upon developing display protocols that a radiologist can effectively utilize. The three parameters used in specifying a digital display are the pixel array size, the pixel dynamic range, and the throughput display rate. The spatial resolution requirements for digital mammography are not known but a number of studies have led to the conclusion that 50-μ pixel sizes are a reasonable choice(10). This implies that each digital mammographic image will require a 4k x 4k pixel display array. The actual dynamic range required of the digital mammography image is also not known exactly but is believed to be between 12 and 14 bits (10) of intensity range. The throughput display rate required

is believed to be approximately 1 to 1.5 seconds per image with the capability of displaying at least four images at a time. Only two display technologies are available for displaying digital mammography images: the high resolution laser film printer (can print 4k x 6k x 12 bit images with optical density ranges of 3.0 on 8x10 inch size film) and the grayscale interactive workstation (a single monitor can display 2k x 2.5 x 8 bit images from a 32 M pixel frame buffer). Studies are needed to determine the acceptable display protocols for the clinical display of digital mammography images.

The advantages of the high resolution laser film printer over a workstation are the following: (a) the spatial resolution of the laser printed digital mammography image matches the acquired digital image (4k x 6k) ; (b) the size of the laser film printed image matches that of the original digital mammography image; and (c) once printed and processed, the laser film printed image can be displayed on mammography view boxes and then managed in the same manner as standard screen film images. The disadvantages of the laser film printer are the following: (a) requires 20 seconds per image for exposing the latent image (prints 1 line per 2.2 msec) and then the standard 90 seconds to develop the film before clinical review of each image is possible; (b) the optical density range is difficult to match operator expectations based on screen-film examination (have to develop acceptable look-up tables); and © the laser film printed image cannot be interactively adjusted for window and level settings.

The advantages of the interactive grayscale workstation are the following: (a) the ability to interactively modify the display image throughout the 12 bit range (window-level, zoom image processing, computer-aided diagnosis algorithms); (b) the use of multiple displays for comparing images (current and previous examinations); © rapid retrieval and display from the archiving storage; and (d) design and use of individual display protocols. The disadvantages of the interactive grayscale workstation for digital mammography are the following: (a) it is only possible to view a 2k x 2.5k portion of the full resolution 4k x 4k image; (b) sub-sampling is required to display the full size digital mammography image; (c) multiple monitors are required for each interactive workstation to display the two CC views and two MLO views; and (d) the user throughput will decrease due to 2k x 2.5k display windows and the use of interactive functions.

3.1 HIGH RESOLUTION LASER FILM PRINTER

None of the current full breat digital mammography units can disply their generated images at full resolution (4k x 6k x2 Bytes per pixel). The currently available high resolution laser printer can print 4k x 5200 lines x 2 Bytes per pixel. This printer is a Kodak printer and we are wrking with it and Kodak to determine the best way to print 4k x 6k x 2 Bytes per pixel.

The high resolution laser filim printer requires well-designed look-up tables for printing digital mammography images. A digital mammography unit generates 12-bit pixel intensity values; the laser printer accepts 12 bits into its memory unit but prints 8 bits, according to definitions in the look-up table. New look-up tables can be installed in the laser imager. The investigators for this project has had extensive experience in developing and installing look-up tables. The look-up tables were designed for use with a laser imager with an OD range of 0.2 to 3.0. On the UVA PACS we have implemented selectable look-up tables for a 3M Corp. laser film printer (8-bit look-up tables). These look-up tables have proven excellent for displaying anatomic objects in the printed image. The standard features of abnormal mammograms are of interest: masses, microcalcifications, architectural distortion, and focal asymmetries. As a starting point, we have adopted 16 graphs similar to the look-up tables used in the FUJI computed radiography system.

During the third year, we will evaluate the curves as follows. Two experiments will be conducted: a contrast-detail study using a phantom and 15 cases from the digital mammography unit, each showing one of the mammographic features of interest. An evaluation will be conducted to determine the best look-up table for printing digital mammography images with mammographic features. This will be accomplished by having four mammographers rate all the images, using the scale; 1= definitely visible; 2= probably visible; 3= equivocal; 4= probably not visible; and 5= definitely not visible. An average of these reader scores will be calculated. The result of this study will be the selection of the optimum look-up tables for the laser imager.

For daily QC of the laser imager, we will employ four internally generated test patterns. These will be printed and developed using a standard film processor which is subject to the daily QC dictated by MQSA. The imager calibration test pattern has 17 bars of gray-level densities, in increments beginning with 0.18 OD.

A densitometer is used to determine if the change in density from one bar to the next is correct and approximately constant for a linear look-up table. The attenuator test measures 32 positions of the attenuator. The universal test pattern prints resolution bars with spacing down to one pixel. The flat gray test pattern print out is stored as a record of the laser engine performance.

3.2 GRAYSCALE DISPLAY FUNCTIONS

The interactive grayscale, 2-monitor, workstation provides image manipulation and enhancement functions through use of a graphical user interface (GUI). The following performance functions are already implemented: (a) worklist/ patient list; (b) soft button using icons; (c) image selection by mouse-driven cursor; (d) image rearrangement and display; (e) double click image to full size; (f) next exam; (g) image enhancements; (h) window-level setting; (i) automatic histogram equalization; (j) inverse video; (k) zoom; (l) image roam; (m) digital magnifying glass; (n) rotation and flip; (o) undo function; (p) system working message; and (q) screen saver.

The interactive grayscale user display functions that are to be added during this research are the following: (a) electronic shutter; (b) image data compression (wavelet image compression at 50:1 and a screen message stating that the displayed image is compressed); (c) nonlinear look-up tables, similar to those of the FUJI look-up tables (message on display screen stating that non-linear look-up tables are in use); (d) DICOM 3.0 data from digital mammography unit to be displayed in a screen window (radiation exposure parameters, patient ID number, patient name, menstruation history, annotations, additional image marking, identified follow-up examinations, and BIRADS data); and (f) the design and implementation of 10 display protocols to be evaluated. An example is: Monitor 1 displays a current exam (craniocaudal [CC], left and right breast, mediolateral oblique [MLO], left and right breast); Monitor 2 meanwhile displays either previous exams if available (CC-L&R; MLO-L&R) or previous and current left CC; previous and current left MLO; etc.). Two significant efforts are required to implement acceptable display protocols for a digital mammography gray-scale workstation: (a) development and evaluation of the protocols; and (b) hardware implementation.

The main difficulty for grayscale display monitors is the development of display protocols for 4k x 6k x 2 Bytes

per pixel images. We will trade off the screen display of 2k x 2k images and of the 4k x 6k full breast digital images.

YEAR 4

TASK 2: Aim 5

- Evaluate the end-to-end image quality control protocol for the teleradiology system.

TASK 3: Aim 6

- Evaluate the performance evaluation of the teleradiology system .
- Continue with utilization of the teleradiology system to increase the statistical power of the analysis.

The Archiving Problem For Full Breast Digital Mammography Units

We have digitized 400 film-screen examinations, 200 normal (left and right breast, CC and MLO screening views. All of the 400 cases were digitized at 50 micron spot size and 50 of the library were also digitized at 70 micron spot size. This digitized mammography library is archived on 50 4mm Data Tape, DDS-90, 3M tapes (4mm x 90 m, 295 feet). We have a database for pointing to the patient examinations. All patient digitized mammograms are coded.

The library is a huge amount of data and takes many hours to read into our SUN workstation. The goal for third year is to place this data on CD-ROM's for easier access. The images are to be archived together with the BIRAD encoded data for each digitized examination.

4. Telemammography Communication Trials

Two communication links are being evaluated for telemammography. The Advanced Communications Technology Satellite (ACTS) will be used between the Cleveland Clinic, the NASA Lewis research Center, and the University of Virginia. A Frame Relay link will be evaluated between The Medical College of Virginia, Nelson Clinic and the

NASA
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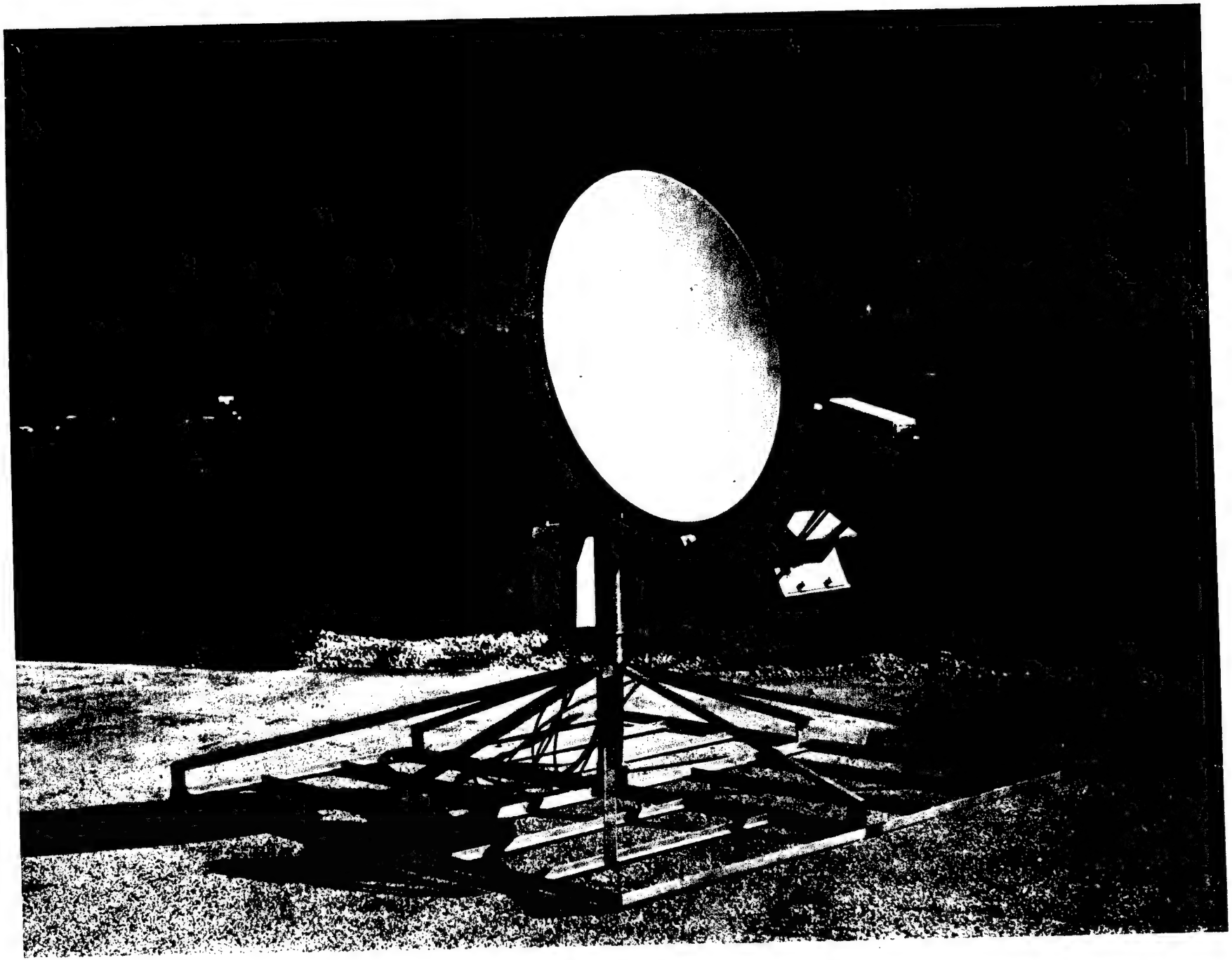

MCV satellite practice in Blauster, Virginia (using 32:1 wavelet compression). Both of these telemammography communication links require a method for displaying the transmitted images.

4.1 Advanced Communications Technology Satellite (ACTS)

The investigators have an in-linked grant from NASA to investigate the application of the ACTS for telemammography. A three way link is to be evaluated between UVA, Cleveland Clinic, and NASA Lewis Research Center. The primary objective is to utilize a set of digitized screen film mammogram (50 micron spot size, 4 k x 6k x 2 Bytes per image) over the ACTS satellite link).

The ACTS was launched in September 1993 by the space shuttle Discovery (STS-51). The ACTS is in a geosynchronous orbit about 19,000 miles above the equator at 100 degrees W longitude.

The ACTS is an experimental test-bed designed to demonstrate on demand communication links. The significant features of the ACTS is a multi-beam antenna, broadband processor, and a microwave switch matrix. The k-band frequencies are used (uplink 27.5-30.0 Ghz and downlink 17.7-20.2 Ghz). The ka band (2.5 Ghz bandwidth) is being used for reduced antenna size and for high capacity datarates.

The antenna being used is the ACTS T1 VSAT with a 1.2 M diameter. This antenna is placed on a roof in a line-of-site position of the ACTS. The weight is minimal so that it is not necessary to have it roof mounted. The T1 VSAT is an active-phased array antenna consisting of a multi-layered microstrip, EM-coupled slot and dipole monolithic microwave integrated circuit (MMIC).

Several categories of digital mammography images are to be transmitted across the ACTS/MMIC satellite link. They will include the following: a.) laser digitized analog film-screen mammography examinations (4k x 4k x 2 Bytes per image). This experiment will run between 15 November 1996 to 15 January 1997.

Due to the problem of digital mammography display, the ACTS/MMIC satellite link experiment will be a round-robin protocol such as: a.) UVA to ACTS back to UVA and printed on the high resolution laser film printer (4k x 5200 x 12 bits); b.) Cleveland Clinic to NASA Lewis Research Center then to UVA (three legs). UVA has the high resolution laser film printer that will be used to capture the resultant transmitted images. The laser film printed images will then be printed and graded on a 1 to 5 scale with 1 being the "best". The film-screen images being used have already been graded and will be compared to the transmitted laser printed films. Some bias will be acquired but use of the grayscale workstation will not enable an adequate comparison.

4.2 Frame Relay Communication.

During the third year of the US Army contract, we will install a Frame Relay connection between The Medical College of Virginia (MCV), Nelson Clinic, and Blauster mammography practice. The cost is to be provided by UVA. A Frame Relay is a virtual leased line, reasonable in cost. We will install a 56 K bps Frame Relay link with a 32 to 1 wavelet image compression technique. UVA now uses this type of communication for its Teleradiology System.

A high resolution AGFA laser film printer (4k x 5k x 12 bits) will be used to display the transmitted images. A two monitor AGFA workstation (2k x 2k x 12 bits) has been

developed and will be demonstrated at the InfoRAD RSNA `97 meeting (December 1996). The display software protocols already developed will be utilized.

5. Conclusions

Implications of completed work at the end of the second year of activity we find several important results. They are the following:

A.) There is a significant need to develop a display system for digital mammography examinations.

At 50 micron spot size laser-film digitized analog film- screen examinations, the digital array size is 4k x 5k x 12 bits. The full breast digital mammography systems generate a 40 micron pixel spot size, the result being 4k x 6k x 2 Bytes per pixel.

The two methods for displaying any digital image, are with a laser film printer and an interactive grayscale display workstation. A high resolution laser film printer (4k x 5200 x 2 Bytes per pixel) is the likely choice for displaying digital mammography. Our 50 micron digitized analog film screen mammography examinations (a library of 400 examinations) are 4k x 5k x 12 bits. We have a high resolution Kodak laser film printer (4k x 5200 lines x 12 bits) which is more than adequate for our digitized library. However, our FBDM unit produces a 4.2k x 6.4k x 2 Bytes digital image. We are working to fit this FBDM array into the Kodak printer array. Very carefully designed lookup tables have been implemented and are being tested.

A serious difficulty has surfaced in the use of our UVA PACS two monitor, 2k x 2.5k x 8/12 bit workstations. The frame buffer is 16 M Pixels but is portioned such that only 2k x 2.5k images can be stored. This means that the 4k x 4k x 12 bit 50 micron images can not be displayed. We have studied all possible methods but ESYSTEMS Software Staff are unwilling to modify this software. Our department is replacing the E-Systems PACS and will use two monitor, 2k x 2k x 12 bit workstations in the near future. We

have acquired such a workstation (AGFA) and are now installing the software.

B.) Interactive Grayscale Workstation Display Protocols

Acceptable display protocols are critical in using interactive gray-scale monitors. The acceptability of a protocol for displaying mammographic images may be judged in terms of the rapidity with which a user can accomplish the reading tasks. Image processing and management steps impact the throughput rate of a display protocol, as do the demands of mammographers for specific organizations of images on the screen. As an example, one possible display protocol for a two-monitor workstation might be defined as follows. Monitor 1 displays a current exam (craniocaudal (CC), left and right breasts; mediolateral oblique (MLO), left and right breasts). Monitor 2 meanwhile displays either previous exams if available (CC-L&R; MLO-L&R) or previous and current left CC; previous and current left MLO; etc. Data from the radiology and the hospital information systems are displayed. Pre-set window and level functions could aid throughput, as could prefetching (acquiring the patients images from the archive file and storing on the workstation, an unacceptable time delay. The image display format is consistent with the way in which they will be reviewed in the clinical setting. Mammograms are typically viewed as mirror images, and if a lesion is identified in one breast the two views of that breast are reviewed.

Examinations will be stored in the following sequences:

1. Left Mediolateral Oblique (MLO)
   Right MLO

2. Left Craniocaudal (CC)
   Right (CC)

3. Left MLO and Left CC

4. Right MLO and Right CC

Two significant efforts are required to implement acceptable display protocols for a digital mammography gray-scale workstation; (a.) development and evaluation of the protocols; and (b.) hardware implementation.

First, we will have designed several plausible display protocols. Second, we will evaluate the protocols by transferring 40 digitized screen-film mammography cases from the PACS to an optical disk. These cases will be equally divided among masses, microcalifications, architectural distortions, and focal asymmetries. The optical disks will have the images preloaded for each of the display protocols to avoid biasing the protocol evaluation with the frustration of the mammography in loading a prescribed sequence. Third, four UVA and MCV mammographers will evaluate the image quality in demonstrating the lesions using each of the display protocols. A reader rating scale will be used for each case (Example, mass:1 = definitely acceptable; 2 = probably acceptable; 3 = equivocal; 4 = probably unacceptable; and 4 = definitely unacceptable). The order of each question will be randomized as well as the cases. The reader data will be analyzed for the mean score.

The times of initiation and completion of each study will be recorded for calculating the throughput times. A preferred display protocol will be identified on the basis of the mean score and a t-test.

The hardware effort is to implement the best display protocols, as evaluated by the mammography readers, onto the hardware platform. For the two-monitor system,

using the AGFA system as a test bed, we will incorporate the selected display protocol onto a DSP board using toolkits provided by HP. HP is just now announcing their new accelerate board; we expect to have it available on-site by February 1996.

We are currently evaluating a set of display protocols.

C.) Through-put Performance

Cost-benefit analyses for digital telemammography lie in the distant future, as they will need to reflect currently nonexistent relationships among costs, availability, efficacy, and quality-of-life feats. An opportunity to analyze initial costs, however, l in the present, created by the availability of the digital mammography environment described in this application. We have devised a cost analysis method in which, for any well-defined system, time can be used to create a relationship between the jobs accomplished per unit of time (the throughput rate) and resources used (costs) to accomplish those jobs. This novel strategy should be applicable to any mammography setting, or for that matter, to any clinical setting.

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APPENDIX 1

Register Report by Category

9/15/94 Through 8/30/96

Date	Num	Description	Memo	Category	Clr	Amount
	INFLOWS					
	Bal Fwd-5-25043 Dwyer					
9/15/94		Opening Balance		[5-25043 Dwyer]	R	653,366.00
	TOTAL TO 5-25043 Dwyer					653,366.00
	TOTAL INFLOWS					653,366.00
	OUTFLOWS					
	20000:					
	21100					
9/15/95		Fac Salary to date	To date	20000:21100		-27,835.35
10/13/...		Brookeman, James R	Pay period end: 10/7	20000:21100		-342.64
10/13/...		Dwyer, Samuel J, III	Pay period end: 10/7	20000:21100		-1,540.00
10/27/...		Brookeman, James	Pay period end: 10/21	20000:21100		-342.64
10/27/...		Dwyer, Samuel J, III	Pay period end: 10/21	20000:21100		-1,540.00
11/10/...		Brookeman, James	11/4 pay period	20000:21100		-342.64
11/10/...		Dwyer, Samuel J, III	11/4 pay period	20000:21100		-1,540.00
11/24/...		Dwyer, Samuel J, III	11/18 pay period	20000:21100		-1,540.00
11/24/...		Brookeman, James	11/18 pay period	20000:21100		-342.64
12/8/95		Brookeman, James	12/02 pay period	20000:21100		-338.75
12/8/95		Dwyer, Samuel J, III	12/02 pay period	20000:21100		-1,522.39
12/22/...		Brookeman, James R	12/16 pay period	20000:21100		-343.33
12/22/...		Dwyer, Samuel J, III	12/16 pay period	20000:21100		-1,538.53
1/5/96		Dwyer, Samuel J, III	12/30 pay period	20000:21100		-1,538.54
1/5/96		Brookeman, James	12/30 pay period	20000:21100		-343.32
1/19/96		Dwyer, Samuel J, III	1/13 pay period	20000:21100		-1,538.53
1/19/96		Brookeman, James R.	1/13 pay period	20000:21100		-343.33
2/2/96		Dwyer, Samuel J, III	1/27 pay period	20000:21100		-1,538.53
2/2/96		Brookeman, James	1/27 pay period	20000:21100		-343.33
2/15/96		Dwyer, Samuel J, III	2/10 pay period	20000:21100		-1,538.53
2/15/96		Brookeman, James	2/10 pay period	20000:21100		-343.33
3/1/96		Brookeman, James	2/24 pay period	20000:21100		-343.33
3/1/96		Dwyer, Samuel J, III	2/24 pay period	20000:21100		-1,538.53
3/9/96		Brookeman, James	3/09 pay period	20000:21100		-343.33
3/9/96		Dwyer, Samuel J, III	3/09 pay period	20000:21100		-1,538.53
3/23/96		Brookeman, James	3/23 pay period	20000:21100		-343.33
3/23/96		Dwyer, Samuel J, III	3/23 pay period	20000:21100		-1,538.53
4/6/96		Brookeman, James	4/06 pay period	20000:21100		-343.33
4/6/96		Dwyer, Samuel J, III	4/06 pay period	20000:21100		-1,538.53
4/20/96		Dwyer, Samuel J, III	4/20 pay period	20000:21100		-1,538.53
4/20/96		Brookeman, James	4/20 pay period	20000:21100		-343.33
5/4/96		Brookeman, James	5/04 pay period	20000:21100		-343.33
5/4/96		Dwyer, Samuel J, III	5/04 pay period	20000:21100		-1,538.53
5/18/96		Brookeman, James	5/18 pay period	20000:21100		-343.33
5/18/96		Dwyer, Samuel J, III	5/18 pay period	20000:21100		-1,538.53
6/1/96		Dwyer, Samuel J, III	6/01 pay period	20000:21100		-1,538.53
6/1/96		Brookeman, James	6/01 pay period	20000:21100		-343.33
6/15/96		Dwyer, Samuel J, III	6/15 pay period	20000:21100		-1,538.53
6/15/96		Brookeman, James	6/15 pay period	20000:21100		-343.33
7/2/96		Brookeman, James	6/29 pay period	20000:21100		-343.33
7/2/96		Dwyer, Samuel J, III	6/29 pay period	20000:21100		-1,538.53
7/13/96		Brookeman, James	7/13 pay period	20000:21100		-343.32

Register Report by Category
9/15/94 Through 8/30/96

Date	Num	Description	Memo	Category	Clr	Amount
7/13/96		Dwyer, Samuel J, III	7/13 pay period	20000:21100		-1,538.52
8/2/96		Dwyer, Samuel J., III	Pay ending 7/24	20000:21100		-1,538.53
8/2/96		Brookeman, James	Pay ending 7/24	20000:21100		-343.33
8/16/96		Dwyer, Samuel J., III	Pay ending 8/10	20000:21100		-1,538.53
8/16/96		Brookeman, James	Pay ending 8/10	20000:21100		-343.33
8/30/96		Dwyer, Samuel J., III	Pay ending 8/24	20000:21100		-1,538.53
8/30/96		Brookeman, James	Pay ending 8/24	20000:21100		-343.33
		TOTAL 21100				-72,982.37
		22100				
9/15/95		Elias, Beth to date	To date	20000:22100		-27,282.50
11/1/95		Elias, Beth	Oct pay	20000:22100		-3,897.50
11/30/...		Elias, Beth	Nov pay	20000:22100		-3,897.50
12/22/...		Elias, Beth	Dec pay	20000:22100		-3,985.25
1/31/96		Elias, Beth	Jan pay	20000:22100		-3,985.25
2/29/96		Elias, Beth	Feb pay	20000:22100		-3,985.25
3/29/96		Elias, Beth	Mar pay	20000:22100		-3,985.25
4/30/96		Elias, Beth	Apr pay	20000:22100		-3,985.25
5/31/96		Elias, Beth	May pay	20000:22100		-3,985.25
6/30/96		Elias, Beth	June pay	20000:22100		-3,985.25
7/31/96		Elias, Beth	July pay	20000:22100		-3,985.25
8/30/96		Elias, Beth	August pay	20000:22100		-1,449.20
		TOTAL 22100				-68,408.70
		23550				
9/15/95		UVa Temps to date	To date	20000:23550		-637.59
2/29/96		U.Va. Temps	Sam's sec	20000:23550		-162.08
		TOTAL 23550				-799.67
		TOTAL 20000				-142,190.74
		30000:				
		31000:				
		31215				
9/15/95		FB to date	To date	30000:31000:31215		-6,270.40
10/31/...		FB Faculty Oct	Oct FB	30000:31000:31215		-828.36
11/30/...		FB Faculty Nov	FB Fac Nov	30000:31000:31215		-828.36
12/31/...		FB Faculty Dec	FB Fac Dec	30000:31000:31215		-823.46
1/31/96		FB Faculty Jan	FB Fac Jan	30000:31000:31215		-828.02
2/29/96		FB Faculty Feb	FB Feb Fac	30000:31000:31215		-1,242.03
3/31/96		FB Faculty Mar	Fac FB Mar	30000:31000:31215		-828.02
4/30/96		FB Faculty Apr	FB Fac Sal Apr	30000:31000:31215		-828.02
5/31/96		FB Faculty May	FB Fac Sal May	30000:31000:31215		-828.02
6/30/96		FB Faculty June	FB Fac Sal June	30000:31000:31215		-828.02
7/31/96		FB Faculty July	FB Fac Sal July	30000:31000:31215		-828.01
8/30/96		FB Faculty Salary	FB Faculty August	30000:31000:31215		-1,242.03
		TOTAL 31215				-16,202.75

Register Report by Category
9/15/94 Through 8/30/96

Date	Num	Description	Memo	Category	Clr	Amount
	31225					
9/15/95		FB, Class to date	To date	30000:31000:31225		-7,678.08
10/31/...		FB Sal Classified	Oct FB Class	30000:31000:31225		-1,091.30
11/30/...		FB Sal Classified	Nov FB Class	30000:31000:31225		-1,091.30
12/31/...		FB Sal Classified	Dec FB Class	30000:31000:31225		-1,115.87
1/31/96		FB Sal Classified	Jan FB Classified	30000:31000:31225		-1,115.87
2/29/96		FB Sal Classified	Feb FB Classified	30000:31000:31225		-1,115.87
3/31/96		FB Sal Classified	Mar FB Classified	30000:31000:31225		-1,115.87
4/30/96		FB Sal Classified	FB Class Apr	30000:31000:31225		-1,115.87
5/31/96		FB Sal Classified	May FB Classified	30000:31000:31225		-1,115.87
6/30/96		FB Sal Classified	June FB Classified	30000:31000:31225		-1,115.87
7/31/96		FB Sal Classified	July FB Classified	30000:31000:31225		-1,115.87
8/30/96		FB Sal Classified	FB Classified August	30000:31000:31225		-405.78
		TOTAL 31225				-19,193.42
		TOTAL 31000				-35,396.17
		34000:				
	34100					
9/15/95		Travel - to date	To date	30000:34000:34100		-533.98
		TOTAL 34100				-533.98
	34350					
9/15/95		Veh rental to date	To date	30000:34000:34350		-152.32
		TOTAL 34350				-152.32
	34500					
9/15/95		Lodging & other to date	To date	30000:34000:34500		-108.00
		TOTAL 34500				-108.00
		TOTAL 34000				-794.30
		36000:				
	36510					
9/15/95		Other re product	To date	30000:36000:36510		-30.00
11/30/...		Other re product	Nov reproduction	30000:36000:36510		-12.50
		TOTAL 36510				-42.50
	36960					
9/15/95		Contractual Services to...	To date	30000:36000:36960		-1,000.00
		TOTAL 36960				-1,000.00

Register Report by Category
9/15/94 Through 8/30/96

Date	Num	Description	Memo	Category	Clr	Amount
	TOTAL 36000					-1,042.50
	TOTAL 30000					-37,232.97
	71100					
9/15/95		Indirects to date	To date	71100		-37,449.74
10/31/...		Indirects	Oct indirects	71100		-4,982.87
11/30/...		Indirects	Nov indirects	71100		-4,989.37
12/31/...		Indirects	Dec indirects	71100		-5,027.14
1/31/96		Indirects	Jan indirects	71100		-5,040.29
2/29/96		Indirects	Feb indirects	71100		-6,318.42
3/31/96		Indirects	Mar indirects	71100		-5,040.29
4/30/96		Indirects	Apr indirects	71100		-5,040.29
5/31/96		Indirects	May indirects	71100		-5,040.29
6/30/96		Indirects	June indirects	71100		-5,040.29
7/31/96		Indirects	July indirects	71100		-4,943.34
8/30/96		Indirect costs	Indirect Costs - August	71100		-4,458.72
	TOTAL 71100					-93,371.05
	TOTAL OUTFLOWS					-272,794.76
	OVERALL TOTAL					380,571.24

Register Report
9/15/94 Through 8/12/96

10/2/96
5-25046 Dwyer

Date	Num	Description	Memo	Category	Clr	Amount
BALANCE 9/14/94						0.00
9/15/94		Opening Balance		[5-25046 Dwyer]	R	324,945.00
9/15/95		SP Subcontracts to date	To date	30000:36000:36960		-53,127.01
10/31/95		SP Subcontracts	Oct payment	30000:36000:36960		-18,533.71
11/14/95		VCU	Nov payment #1	30000:36000:36960		-507.83
11/17/95		VCU	Nov payment #2	30000:36000:36960		-4,987.43
1/10/96		VCU	Jan payment #2	30000:36000:36960		-9,461.95
1/10/96		VCU	Jan payment #1	30000:36000:36960		-6,481.49
2/23/96		VCU	Feb payment -paid in Mar	30000:36000:36960		-8,543.82
3/18/96		VCU	Mar payment	30000:36000:36960		-8,543.82
4/30/96		VCU	Apr payment	30000:36000:36960		-3,071.18
5/15/96		VCU	May payment	30000:36000:36960		-6,212.90
6/7/96		VCU	June payment	30000:36000:36960		-7,891.64
7/3/96		VCU	July payment	30000:36000:36960		-6,212.90
8/12/96		VCU	August payment	30000:36000:36960		-6,212.90
TOTAL 9/15/94 - 8/12/96						185,156.42
BALANCE 8/12/96						185,156.42
TOTAL INFLOWS						324,945.00
TOTAL OUTFLOWS						-139,788.58
NET TOTAL						185,156.42

APPENDIX 2

CASE #	PARENCHYMAL	GROUP	FINDINGS	DIAGNOSIS
001	3	NORMAL		
002	2	NORMAL		
003	3	ABN	CA, AD, FAD	M
004	3	ABN	CA	B
005	3	ABN	CA	M
006	4	ABN	CA	B
007	4	ABN	MASS	B
008	3	ABN	CA	B
009	1	NORMAL		
010	2	NORMAL		
011	1	NORMAL		
012	2	ABN	MASS	M
013	1	ABN	AD, MASS	M
014	2	ABN	CA	M
015	3	NORMAL		
016	4	NORMAL		
017	1	ABN	MASS	B
018	2	ABN	CA	M
019	2	ABN	CA	M
020	1	ABN	MASS	M
021	2	NORMAL		
022	4	NORMAL		
023	2	ABN	FAD	B
024	3	ABN	FAD	B
025	2	NORMAL		
026	1	NORMAL		
027	4	ABN	CA	B
028	1	NORMAL		
029	1	ABN	MASS	B
030	1	ABN	MASS	B
031	3	NORMAL		
032	3	ABN	FAD	B
033	1	ABN	CA	B
034	2	NORMAL		
035	4	NORMAL		
036	2	ABN	FAD	B
037	3	ABN	CA	B
038	3	NORMAL		
039	2	NORMAL		
040	4	ABN	CA	B

041	4	ABN	CA	B
042	2	NORMAL		
043	4	NORMAL		
044	2	NORMAL		
045	3	ABN	FAD	M
046	4	NORMAL		
047	3	NORMAL		
048	2	NORMAL		
049	4	NORMAL		
050	2	NORMAL		
051	2	ABN	CA	B
052	3	NORMAL		
053	1	NORMAL		
054	1	NORMAL		
055	1	ABN	MASS	B
056	1	ABN	CA	B
057	1	ABN	MASS	B
058	2	NORMAL		
059	4	NORMAL		
060	1	NORMAL		
061	4	ABN	CA	B
062	2	NORMAL		
063	1	NORMAL		
064	3	NORMAL		
065	1	ABN	MASS	B
066	3	NORMAL		
067	4	NORMAL		
068	3	ABN	CA	M
069	3	ABN	MASS	B
070	3	NORMAL		
071	3	ABN	CA	B
072	3	ABN	CA	M
073	1	NORMAL		
074	2	ABN	CA	M
075	1	NORMAL		
076	4	NORMAL		
077	4	NORMAL		
078	3	ABN	MASS	B
079	2	ABN	MASS	B
080	2	ABN	MASS	M
081	3	ABN	CA	M
082	3	ABN	CA	B
083	1	NORMAL		
084	2	NORMAL		
085	1	NORMAL		

086	3	ABN	MASS	M
087	3	ABN	CA	M
088	1	ABN	CA	B
089	3	ABN	FAD	B
090	3	ABN	MASS	B
091	4	ABN	CA	M
092	3	NORMAL		
093	1	NORMAL		
094	1	ABN	MASS, CA	M
095	1	ABN	MASS	M
096	4	NORMAL		
097	4	NORMAL		
098	1	NORMAL		
099	4	NORMAL		
100	3	ABN	MASS	M
101	3	NORMAL		
102	3	ABN	AD	M
103	4	ABN	CA	M
104	1	ABN	MASS	M
105	3	NORMAL		
106	2	ABN	MASS	B
107	1	NORMAL		
108	2	ABN	AD	M
109	4	ABN	CA	M
110	1	NORMAL		
111	3	ABN	FAD	M
112	2	NORMAL		
113	3	ABN	FAD	M
114	3	ABN	CA	M
115	2	NORMAL		
116	2	NORMAL		
117	1	NORMAL		
118	1	ABN	MASS	B
119	4	NORMAL		
120	1	NORMAL		
121	3	NORMAL		
122	4	NORMAL		
123	4	ABN	CA	B
124	1	ABN	CA	M
125	3	ABN	CA	B
126	1	ABN	FAD	B
127	4	NORMAL		
128	2	ABN	CA	B
129	4	ABN	CA	M
130	1	NORMAL		

131	3	NORMAL		
132	3	ABN	CA	B
133	1	ABN	CA	M
134	1	ABN	CA	B
135	2	NORMAL		
136	3	NORMAL		
137	2	NORMAL		
138	3	ABN	MASS	M
139	2	ABN	FAD	M
140	3	NORMAL		
141	1	NORMAL		
142	3	ABN	MASS	M
143	4	ABN	MASS	M
144	3	ABN	CA	B
145	4	NORMAL		
146	1	ABN	MASS	M
147	1	NORMAL		
148	2	NORMAL		
149	4	NORMAL		
150	3	NORMAL		
151	1	ABN	MASS	B
152	4	NORMAL		
153	1	ABN	MASS	M
154	4	NORMAL		
155	3	NORMAL		
156	2	ABN		B
157	3	NORMAL		
158	4	NORMAL		
159	4	NORMAL		
160	3	ABN		M
161	2	ABN	CA	B
162	2	NORMAL		
163	3	ABN		B
164	3	ABN	AD	M
165	2	NORMAL		
166	1	ABN	FAD	M
167	4	NORMAL		
168	4	ABN		B
169	4	ABN	CA	B
170	1	ABN	MASS	M
171	3	NORMAL		
172	2	NORMAL		
173	3	NORMAL		
174	4	ABN		B
175	4	ABN	MASS	M

176	4	NORMAL		
177	1	NORMAL		
178	3	ABN	FCC	B
179	2	ABN	CA	B
180	4	NORMAL		
181	2	ABN	MASS	B
182	4	NORMAL		
183	2	NORMAL		
184	3	NORMAL		
185	1	NORMAL		
186	1	ABN	CA	B
187	3	ABN	MASS	M
188	3	ABN	MASS	M
189	4	NORMAL		
190	2	NORMAL		
191	3	ABN	CA	B
192	4	ABN	CA	M
193	3	NORMAL		
194	3	ABN		M
195	3	ABN	MASS	M
196	2	ABN	MASS	M
197	1	NORMAL		
198	2	NORMAL		
199	3	NORMAL		
200	3	ABN	MASS, CA	M
201	2	NORMAL		
202	1	ABN		M
203	2	NORMAL		
204	3	NORMAL		
205	2	ABN		M
206	2	ABN		B
207	3	NORMAL		
208	4	ABN	MASS	B
209	3	NORMAL		
210	2	ABN	CA	M
211	1	NORMAL		
212	4	ABN		M
213	4	NORMAL		
214	4	ABN	CA	M
215	1	NORMAL		
216	4	ABN	CA	M
217	2	NORMAL		
218	4	NORMAL		
219	3	ABN	CA	M
220	1	NORMAL		

221	3	NORMAL		
222	3	ABN		M
223	1	NORMAL		
224	1	NORMAL		
225	1	NORMAL		
226	1	NORMAL		
227	3	NORMAL		
228	3	ABN	CA	M
229	1	NORMAL		
230	3	ABN	FAD	B
231	3	ABN	MASS	M
232	4	NORMAL		
233	3	ABN	MASS	M
234	3	ABN	AD	B
235	1	NORMAL		
236	1	NORMAL		
237	4	ABN	CA	M
238	1	ABN	CA	M
239	2	NORMAL		
240	1	NORMAL		
241	2	ABN		M
242	3	NORMAL		
243	1	ABN	MASS	M
244	2	ABN	MASS	M
245	3	NORMAL		
246	4	ABN		B
247	4	ABN	CA	B
248	1	ABN		B
249	2	ABN	CA	M
250	1	ABN	CA	B
251	3	ABN	MASS	M
252	3	NORMAL		
253	2	ABN	MASS	M
254	1	ABN	CA	M
255	4	NORMAL		
256	4	NORMAL		
257	2	ABN	CA	M
258	1	NORMAL		
259	2	ABN	MASS	B
260	4	NORMAL		
261	3	ABN	CA	B
262	2	NORMAL		
263	1	ABN	MASS	M
264	1	ABN	CA	B
265	4	ABN	CA	M

266	2	NORMAL		
267	1	NORMAL		
268	1	ABN	FAD	B
269	2	NORMAL		
270	2	ABN	CA	M
271	3	ABN	CA	M
272	4	NORMAL		
273	3	ABN	CA	M
274	3	NORMAL		
275	2	ABN	CA	M
276	4	ABN	CA	M
277	2	NORMAL		
278	4	NORMAL		
279	3	NORMAL		
280	1	NORMAL		
281	3	NORMAL		
282	3	ABN	CA	B
283	4	ABN	CA	M
284	4	ABN	CA	M
285	3	NORMAL		
286	2	NORMAL		
287	1	ABN	MASS	M
288	4	ABN	CA	M
289	3	NORMAL		
290	1	ABN	MASS	M
291	2	NORMAL		
292	3	NORMAL		
293	3	ABN	CA	M
294	4	NORMAL		
295	3	ABN	CA	B
296	3	ABN	MASS	B
297	2	NORMAL		
298	4	NORMAL		
299	3	ABN	CA	M
300	1	NORMAL		
301	4	ABN	CA	M
302	4	NORMAL		
303	4	NORMAL		
304	3	ABN	CA	M
305	3	ABN	CA	B
306	2	ABN	MASS	B
307	4	NORMAL		
308	4	ABN	FAD	M
309	1	ABN	MASS	M
310	4	NORMAL		

311	4	ABN	FAD	M
312	2	ABN	MASS	M
313	3	NORMAL		
314	3	ABN	CA	M
315	4	NORMAL		
316	2	ABN	MASS	M
317	2	NORMAL		
318	4	NORMAL		
319	3	NORMAL		
320	3	ABN	CA	B
321	4	NORMAL		
322	2	ABN	CA	M
323	4	ABN	CA	M
324	4	ABN	CA	B
325	2	ABN	FAD	B
326	3	NORMAL		
327	2	NORMAL		
328	3	ABN	CA	B
329	2	NORMAL		
330	2	ABN	MASS	B
331	2	NORMAL		
332	1	NORMAL		
333	4	ABN	MASS	M
334	2	ABN	FAD	M
335	1	ABN	MASS	M
336	2	ABN	MASS	M
337	2	ABN	CA	B
338	2	NORMAL		
339	3	NORMAL		
340	2	NORMAL		
341	3	ABN	CA	M
342	3	NORMAL		
343	3	NORMAL		
344	2	NORMAL		
345	2	NORMAL		
346	3	ABN	CA	M
347	2	NORMAL		
348	2	ABN	MASS	B
349	2	NORMAL		
350	2	NORMAL		

KEY

PARENCHYMAL DENSITY:
1=FATTY
2=SCATTERED FIBROGLANDULAR TISSUE
3=HETEROGENEOUSLY DENSE
4= EXTREMELY DENSE

GROUP:

NORMAL=NORMAL
ABN = ABNORMAL

FINDINGS:

MASS=MASS
FAD =FOCAL ASYMMETRIC DENSITY
AD =ARCHITECTURAL DISTORTION
CA =CALCIFICATIONS

DIAGNOSIS:

M=MALIGNANT
B=BENIGN

READERS RESPONSES TO CASE 84

MASS	CALCIFICATION	FAD/AD	DIAGNOSIS	READER #
1	5	1	3	6
2	5	1	2	5
2	2	1	1	4
1	5	1	4	3
1	1	2	2	2
1	2	1	2	7
1	5	1	4	10
1	5	1	3	11

KEY TO FINDINGS:

1=DEFINITELY NOT PRESENT

2=PROBABLY NOT PRESENT

3=EQUIVOCAL

4=PROBABLY PRESENT

5=DEFINITELY PRESENT

KEY TO DIAGNOSIS

1=DEFINITELY BENIGN

2=PROBABLY BENIGN

3=EQUIVOCAL

4=PROBABLY MALIGNANT

5=DEFINITLEY MALIGNANT

READERS SPECIFIC RESPONSES

READER 6

	TRUE NORMALS (149)	TRUE BENIGN (66)	TRUE MALIGNANT (84)
DEFINITELY BENIGN	010	01	00
PROBABLY BENIGN	121	17	14
EQUIVOCAL	017	41	30
PROBABLY MALIGNANT	001	07	25
DEFINITELY MALIGNANT	000	00	15

READER 2

	TRUE NORMALS (149)	TRUE BENIGN (66)	TRUE MALIGNANT (84)
DEFINITELY BENIGN	28	02	01
PROBABLY BENIGN	62	17	06
EQUIVOCAL	59	37	41
PROBABLY MALIGNANT	00	10	23
DEFINITELY MALIGNANT	00	00	13

CLINICAL HISTORY SHEET

MAMMOGRAPHY CLINICAL HISTORY SHEET

HISTORY NO.: _____ DATE OF SERVICE: _____

NAME: LAST _____ FIRST _____ M.I. _____

ADDRESS: _____ ZIP: _____

SSN: _____ DATE OF BIRTH: _____

HOME PHONE NUMBER: (___) ____-_____ WORK PHONE: (___) ____-_____

==========

IS THIS YOUR FIRST MAMMOGRAM? **Y** **N**

IF NO, WHERE WERE YOUR OLD FILMS DONE? _____

WHEN WAS YOUR LAST MAMMOGRAM? _____

HOW OLD WERE YOU WHEN YOUR PERIOD STARTED? _____

WHAT IS THE DATE OF YOUR LAST PERIOD? _____

HAVE YOU EVER HAD A HYSTERECTOMY? Y N

DID THEY REMOVE YOUR OVARIES? Y N

HOW MANY TIMES HAVE YOU BEEN PREGNANT? _____

HOW MANY CHILDREN DO YOU HAVE? _____

HOW OLD WERE YOU WHEN YOUR FIRST CHILD WAS BORN? _____

DO YOU TAKE BIRTH CONTROL PILLS? _____

HAVE YOU EVER HAD CANCER? **Y** **N**

IF YES, WHAT KIND OF CANCER? _____

HAVE ANY OF YOUR FAMILY MEMBERS HAD BREAST CANCER?

MOTHER___ SISTER___ AUNT___ GRANDMOTHER___ OTHER___

GIVE AGE AT DIAGNOSIS: _____

DO YOU HAVE BREAST IMPLANTS? **Y** **N**

IF YES, WHAT KIND OF IMPLANTS? _____

DO YOU TAKE HORMONES? Y N

WHAT KIND OF HORMONES? ESTROGEN____ TAMOXIFIN___

PROGESTERONE___ OTHER_____

AT WHAT AGE DID YOU BEGIN TAKING HORMONES? _____

HAVE YOU EVER HAD BREAST SURGERY? **Y** **N**

IF YES, WHEN AND WHICH BREAST? _____

WHAT WERE THE RESULTS? _____

HAVE YOU EVER HAD RADIATION THERAPY? **Y** **N**

IF YES, WHICH BREAST AND IN WHAT YEAR? _____

HAVE YOU EVER HAD A BREAST REMOVED? **Y** **N**

IF YES, WHICH BREAST? _____

HAVE YOU FOUND ANY NEW LUMPS IN YOUR BREAST? **Y** **N**

IF YES, WHICH BREAST? _____

HOW LONG HAVE YOU HAD THE LUMP? _____

HAS THE LUMP CHANGED? _____

DO YOU HAVE ANY OTHER NEW BREAST PROBLEMS? **Y** **N**

IF YES, PLEASE DESCRIBE: _____

WHEN DID THE PROBLEM START? _____

MAMMOGRAPHIC FINDINGS

acr AMERICAN COLLEGE OF RADIOLOGY INSTITUTE

MagView™

Finding check-off sheets

Patient ID: _____

Patient Name: _____

Examination Date: _____

☐ Prior study dates compared: __/__/____ __/__/____ __/__/____

Finding# _____ of _____

☐ Negative exam

- ☐ Mammogram
- ☐ Ultrasound
- ☐ Ductography

Tissue Density

- ☐ Almost entirely fat
- ☐ Scattered fibroglandular densities
- ☐ Heterogeneously dense
- ☐ Extremely dense

Recommendation

- ☐ Normal interval screening in____ months or by age____
- ☐ Any decision to biopsy should be based on clinical assessment

Initials:_____

☐ Non-Negative Finding

☐ Finding correlates to clinical exam finding in ☐L ☐R ☐B breast(s) at _____ (location)

☐ Follow-up

- ☐ Follow-up of procedure
  - ☐ Lumpectomy
  - ☐ Excisional biopsy
  - ☐ Mastectomy
  - ☐ Needle biopsy
  - ☐ Radiation Therapy

☐ Follow-up of prior finding in ☐L ☐R ☐B breast(s) at _____ (location).

☐ Change

- ☐ No significant changes
- ☐ Increase in size
- ☐ Decrease in size
- ☐ Increase in number of calcifications
- ☐ Decrease in number of calcifications
- ☐ Less defined
- ☐ More defined
- ☐ Completely removed
- ☐ Partially removed

Finding Side: ☐ Left ☐ Right ☐ Both ☐ Multiple similar findings: Approximate number:_____

Mammogram

☐ Not seen on mammogram

Tissue Density (choose one)

- ☐ Almost entirely fat
- ☐ Scattered fibroglandular densities
- ☐ Heterogeneously dense
- ☐ Extremely dense

Mass Shape (choose one)

- ☐ Round
- ☐ Oval
- ☐ Lobular
- ☐ Irregular
- ☐ Architectural distortion
- ☐ Tubular density/solitary dilated duct
- ☐ Intramammary lymph node
- ☐ Asymmetric breast tissue
- ☐ Focal asymmetric density

Margins (choose one)

- ☐ Circumscribed
- ☐ Microlobulated
- ☐ Obscured
- ☐ Indistinct
- ☐ Spiculated

Density (choose one)

- ☐ High density
- ☐ Low density
- ☐ Isodense
- ☐ Fat containing

Calcifications

- ☐ Skin
- ☐ Vascular
- ☐ Coarse
- ☐ Large rod-like
- ☐ Large round
- ☐ Eggshell or rim
- ☐ Milk of calcium
- ☐ Dystrophic
- ☐ Punctate
- ☐ Amorphous or indistinct
- ☐ Heterogeneous or pleomorphic
- ☐ Fine and/or branching
- ☐ Spherical or lucent-centered
- ☐ Suture

Distribution (choose one)

- ☐ Grouped or clustered
- ☐ Segmental
- ☐ Regional
- ☐ Linear
- ☐ Diffuse/scattered

Other findings

- ☐ Nipple retraction
- ☐ Skin thickening
- ☐ Trabecular thickening
- ☐ Skin lesion
- ☐ Axilliary adenopathy
- ☐ Skin retraction
- ☐ Architectural distortion
- ☐ Hematoma
- ☐ Post surgical scar

Implant Findings

- ☐ Asymmetric implant
- ☐ Calcified implant
- ☐ Distorted implant
- ☐ Fibrosed implant
- ☐ Herniated implant
- ☐ Ruptured implant
- ☐ Free silicone
- ☐ Capsular contraction

READER STATUS REPORT

READER	CASES READ (AS OF 09-30-95)
02	1-299
03	1-299
04	1-299
05	1-350
06	1-300
07	1-300
09	1-250
10	1-200
11	1-200
12	1-100
13	1-100

ROC RESULTS OF READERS FOR ANALOG IMAGES

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: [redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 59.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	44.	44.	53.	2.	6.
ACTUALLY POSITIVE CASES	3.	3.	8.	10.	35.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0403 0.0537 0.4094 0.7047 1.0000
TPF: 0.0000 0.5932 0.7627 0.8983 0.9492 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.3744 B= 0.5371
Z(K)= -0.5376 0.2287 1.6104 1.7480
LOGL= -271.0403
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.4609 B= 0.6171
Z(K)= -0.5266 0.2289 1.4998 1.9286
LOGL= -264.3502
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

VARIANCE-COVARIANCE MATRIX:

A	0.0525	0.0197	0.0050	0.0052	0.0045	0.0009
B	0.0197	0.0173	0.0020	0.0011	-0.0052	-0.0117
Z(1)	0.0050	0.0020	0.0116	0.0062	0.0030	0.0021
Z(2)	0.0052	0.0011	0.0062	0.0105	0.0055	0.0047
Z(3)	0.0045	-0.0052	0.0030	0.0055	0.0234	0.0231
Z(4)	0.0009	-0.0117	0.0021	0.0047	0.0231	0.0397

CORRELATION MATRIX:

A	1.0000	0.6523	0.2014	0.2210	0.1284	0.0187
B	0.6523	1.0000	0.1390	0.0823	-0.2592	-0.4476
Z(1)	0.2014	0.1390	1.0000	0.5645	0.1807	0.0962
Z(2)	0.2210	0.0823	0.5645	1.0000	0.3543	0.2323
Z(3)	0.1284	-0.2592	0.1807	0.3543	1.0000	0.7586
Z(4)	0.0187	-0.4476	0.0962	0.2323	0.7586	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4487	(0.2635 ,	0.6460)
0.010	0.5100	(0.3324 ,	0.6855)
0.020	0.5766	(0.4124 ,	0.7283)
0.030	0.6179	(0.4638 ,	0.7551)
0.040	0.6481	(0.5019 ,	0.7751)
0.050	0.6721	(0.5322 ,	0.7911)
0.060	0.6919	(0.5573 ,	0.8046)
0.070	0.7088	(0.5787 ,	0.8163)
0.080	0.7236	(0.5973 ,	0.8266)
0.090	0.7367	(0.6137 ,	0.8359)
0.100	0.7485	(0.6284 ,	0.8443)
0.110	0.7592	(0.6416 ,	0.8520)
0.120	0.7690	(0.6537 ,	0.8591)
0.130	0.7781	(0.6647 ,	0.8656)
0.140	0.7865	(0.6749 ,	0.8718)
0.150	0.7943	(0.6844 ,	0.8775)
0.200	0.8268	(0.7234 ,	0.9015)
0.250	0.8520	(0.7531 ,	0.9200)
0.300	0.8723	(0.7771 ,	0.9348)
0.400	0.9040	(0.8147 ,	0.9568)
0.500	0.9280	(0.8442 ,	0.9719)
0.600	0.9471	(0.8693 ,	0.9826)
0.700	0.9628	(0.8921 ,	0.9901)
0.800	0.9762	(0.9142 ,	0.9952)
0.900	0.9878	(0.9384 ,	0.9985)
0.950	0.9934	(0.9538 ,	0.9995)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0269, 0.6067)	(0.0102, 0.5118)	(0.0620, 0.6956)
(0.0668, 0.7038)	(0.0360, 0.6369)	(0.1151, 0.7644)
(0.4095, 0.9065)	(0.3338, 0.8841)	(0.4887, 0.9256)
(0.7008, 0.9629)	(0.6238, 0.9511)	(0.7696, 0.9723)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 82.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	127.	14.	5.	0.	3.
ACTUALLY POSITIVE CASES	12.	6.	4.	11.	49.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0201 0.0201 0.0537 0.1477 1.0000

TPF: 0.0000 0.5976 0.7317 0.7805 0.8537 1.0000

INITIAL VALUES OF PARAMETERS:

A= 1.8080 B= 0.6820

Z(K)= 1.0466 1.6104 1.9514 2.0514

LOGL= -191.9226

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:

A= 1.8169 B= 0.6938

Z(K)= 1.0526 1.5531 1.8560 2.2459

LOGL= -184.4330

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.1216	0.0618	0.0150	0.0032	-0.0095	-0.0326
B	0.0618	0.0410	0.0038	-0.0066	-0.0169	-0.0348
Z(1)	0.0150	0.0038	0.0159	0.0128	0.0112	0.0092
Z(2)	0.0032	-0.0066	0.0128	0.0233	0.0235	0.0254
Z(3)	-0.0095	-0.0169	0.0112	0.0235	0.0350	0.0406
Z(4)	-0.0326	-0.0348	0.0092	0.0254	0.0406	0.0667

CORRELATION MATRIX:

A	1.0000	0.8756	0.3411	0.0600	-0.1452	-0.3622
B	0.8756	1.0000	0.1502	-0.2124	-0.4452	-0.6656
Z(1)	0.3411	0.1502	1.0000	0.6645	0.4752	0.2833
Z(2)	0.0600	-0.2124	0.6645	1.0000	0.8240	0.6448
Z(3)	-0.1452	-0.4452	0.4752	0.8240	1.0000	0.8409
Z(4)	-0.3622	-0.6656	0.2833	0.6448	0.8409	1.0000

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.5118	(0.3057 ,	0.7147)
0.010	0.5803	(0.3971 ,	0.7473)
0.020	0.6524	(0.4987 ,	0.7843)
0.030	0.6956	(0.5595 ,	0.8089)
0.040	0.7264	(0.6018 ,	0.8279)
0.050	0.7503	(0.6334 ,	0.8438)
0.060	0.7697	(0.6581 ,	0.8574)
0.070	0.7861	(0.6781 ,	0.8693)
0.080	0.8001	(0.6947 ,	0.8799)
0.090	0.8123	(0.7088 ,	0.8894)
0.100	0.8232	(0.7209 ,	0.8979)
0.110	0.8329	(0.7315 ,	0.9056)
0.120	0.8417	(0.7409 ,	0.9126)
0.130	0.8498	(0.7493 ,	0.9190)
0.140	0.8571	(0.7569 ,	0.9248)
0.150	0.8639	(0.7638 ,	0.9302)
0.200	0.8912	(0.7911 ,	0.9511)
0.250	0.9114	(0.8111 ,	0.9654)
0.300	0.9269	(0.8269 ,	0.9753)

0.400	0.9496	(	0.8517 ,	0.9874	)
0.500	0.9654	(	0.8715 ,	0.9938	)
0.600	0.9768	(	0.8887 ,	0.9972	)
0.700	0.9854	(	0.9047 ,	0.9989	)
0.800	0.9918	(	0.9210 ,	0.9997	)
0.900	0.9966	(	0.9395 ,	0.9999	)
0.950	0.9985	(	0.9519 ,	1.0000	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0124, 0.6021)	(0.0030, 0.4632)	(0.0410, 0.7291)
(0.0317, 0.7017)	(0.0131, 0.6083)	(0.0682, 0.7834)
(0.0602, 0.7702)	(0.0320, 0.7026)	(0.1049, 0.8282)
(0.1463, 0.8614)	(0.0968, 0.8199)	(0.2103, 0.8958)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA:

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 27.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	93.	27.	10.	10.	9.
ACTUALLY POSITIVE CASES	6.	0.	2.	8.	11.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0604 0.1275 0.1946 0.3758 1.0000
TPF: 0.0000 0.4074 0.7037 0.7778 0.7778 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.3079 B= 0.8539
Z(K)= 0.3160 0.8608 1.1383 1.5517
LOGL= -209.1670
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AF

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.1742 B= 0.8234
Z(K)= 0.3269 0.8058 1.0795 1.6264
LOGL= -208.0945
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.1161	0.0609	0.0099	0.0079	0.0057	-0.0022

B	0.0609	0.0596	0.0035	-0.0003	-0.0037	-0.0152
Z(1)	0.0099	0.0035	0.0109	0.0082	0.0071	0.0053
Z(2)	0.0079	-0.0003	0.0082	0.0129	0.0114	0.0095
Z(3)	0.0057	-0.0037	0.0071	0.0114	0.0155	0.0134
Z(4)	-0.0022	-0.0152	0.0053	0.0095	0.0134	0.0283

CORRELATION MATRIX:

A	1.0000	0.7313	0.2783	0.2036	0.1354	-0.0388
B	0.7313	1.0000	0.1356	-0.0097	-0.1210	-0.3698
Z(1)	0.2783	0.1356	1.0000	0.6919	0.5454	0.3029
Z(2)	0.2036	-0.0097	0.6919	1.0000	0.8055	0.4983
Z(3)	0.1354	-0.1210	0.5454	0.8055	1.0000	0.6430
Z(4)	-0.0388	-0.3698	0.3029	0.4983	0.6430	1.0000

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1718	(0.0344 ,	0.4705)
0.010	0.2291	(0.0648 ,	0.5128)
0.020	0.3025	(0.1171 ,	0.5617)
0.030	0.3539	(0.1613 ,	0.5946)
0.040	0.3945	(0.1999 ,	0.6205)
0.050	0.4284	(0.2341 ,	0.6422)
0.060	0.4577	(0.2647 ,	0.6614)
0.070	0.4836	(0.2924 ,	0.6786)
0.080	0.5068	(0.3176 ,	0.6944)
0.090	0.5279	(0.3407 ,	0.7091)
0.100	0.5473	(0.3618 ,	0.7228)
0.110	0.5652	(0.3813 ,	0.7357)
0.120	0.5819	(0.3994 ,	0.7480)
0.130	0.5974	(0.4162 ,	0.7596)
0.140	0.6120	(0.4318 ,	0.7707)
0.150	0.6258	(0.4464 ,	0.7812)
0.200	0.6849	(0.5071 ,	0.8276)
0.250	0.7321	(0.5534 ,	0.8652)
0.300	0.7712	(0.5905 ,	0.8955)
0.400	0.8330	(0.6483 ,	0.9396)
0.500	0.8798	(0.6937 ,	0.9673)
0.600	0.9166	(0.7329 ,	0.9840)
0.700	0.9458	(0.7695 ,	0.9933)
0.800	0.9691	(0.8068 ,	0.9979)
0.900	0.9871	(0.8502 ,	0.9997)
0.950	0.9943	(0.8798 ,	0.9999)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0519, 0.4345)	(0.0252, 0.3313)	(0.0974, 0.5424)

(0.1402, 0.6123) (0.0929, 0.5337) (0.2016, 0.6865)
(0.2102, 0.6952) (0.1519, 0.6284) (0.2798, 0.7561)
(0.3719, 0.8173) (0.2974, 0.7692) (0.4515, 0.8586)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 150.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	28.	62.	59.	0.	0.
ACTUALLY POSITIVE CASES	3.	23.	78.	33.	13.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.3960 0.8121 1.0000
TPF: 0.0000 0.0867 0.3067 0.8267 0.9800 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.2603 B= 0.8325
Z(K)= -0.8855 0.2634 2.6112 2.7112
LOGL= -397.9249
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 7 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.2232 B= 0.6858
Z(K)= -0.9217 0.3090 2.5500 3.7878
LOGL= -345.4767
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	0.0189	0.0045	0.0052	0.0060	0.0056	-0.0005
B	0.0045	0.0099	0.0027	-0.0001	-0.0269	-0.0459
Z(1)	0.0052	0.0027	0.0140	0.0051	-0.0023	-0.0073
Z(2)	0.0060	-0.0001	0.0051	0.0103	0.0087	0.0091
Z(3)	0.0056	-0.0269	-0.0023	0.0087	0.1115	0.1582
Z(4)	-0.0005	-0.0459	-0.0073	0.0091	0.1582	0.2801

CORRELATION MATRIX:

A	1.0000	0.3270	0.3178	0.4283	0.1216	-0.0072
B	0.3270	1.0000	0.2319	-0.0120	-0.8074	-0.8706
Z(1)	0.3178	0.2319	1.0000	0.4245	-0.0585	-0.1170
Z(2)	0.4283	-0.0120	0.4245	1.0000	0.2583	0.1695
Z(3)	0.1216	-0.8074	-0.0585	0.2583	1.0000	0.8953
Z(4)	-0.0072	-0.8706	-0.1170	0.1695	0.8953	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED

FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.2934	(0.1514 ,	0.4775)
0.010	0.3548	(0.2065 ,	0.5294)
0.020	0.4264	(0.2779 ,	0.5864)
0.030	0.4734	(0.3282 ,	0.6222)
0.040	0.5089	(0.3680 ,	0.6488)
0.050	0.5379	(0.4012 ,	0.6702)
0.060	0.5623	(0.4298 ,	0.6881)
0.070	0.5836	(0.4550 ,	0.7037)
0.080	0.6024	(0.4776 ,	0.7174)
0.090	0.6193	(0.4981 ,	0.7297)
0.100	0.6347	(0.5169 ,	0.7409)
0.110	0.6488	(0.5341 ,	0.7512)
0.120	0.6618	(0.5502 ,	0.7608)
0.130	0.6739	(0.5651 ,	0.7696)
0.140	0.6852	(0.5791 ,	0.7779)
0.150	0.6958	(0.5922 ,	0.7857)
0.200	0.7409	(0.6482 ,	0.8191)
0.250	0.7766	(0.6924 ,	0.8460)
0.300	0.8062	(0.7287 ,	0.8684)
0.400	0.8531	(0.7859 ,	0.9045)
0.500	0.8894	(0.8299 ,	0.9322)
0.600	0.9187	(0.8659 ,	0.9541)
0.700	0.9432	(0.8970 ,	0.9713)
0.800	0.9641	(0.9253 ,	0.9846)
0.900	0.9822	(0.9534 ,	0.9942)
0.950	0.9906	(0.9692 ,	0.9977)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0001, 0.0847)	(0.0000, 0.0185)	(0.0030, 0.2537)
(0.0054, 0.2996)	(0.0007, 0.1650)	(0.0290, 0.4695)
(0.3787, 0.8441)	(0.3059, 0.8093)	(0.4560, 0.8744)
(0.8217, 0.9682)	(0.7548, 0.9551)	(0.8757, 0.9780)

1

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

DATA DESCRIPTION [redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 59.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	100.	41.	1.	6.	1.
ACTUALLY POSITIVE CASES	6.	6.	3.	10.	34.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0067 0.0470 0.0537 0.3289 1.0000
TPF: 0.0000 0.5763 0.7458 0.7966 0.8983 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.5514 B= 0.5243
Z(K)= 0.4426 1.6104 1.6752 2.4728
LOGL= -197.8084
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.5534 B= 0.5279
Z(K)= 0.4474 1.5513 1.7104 2.5634
LOGL= -196.4182
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.0741	0.0289	0.0066	0.0035	0.0017	-0.0209
B	0.0289	0.0197	0.0019	-0.0042	-0.0064	-0.0298
Z(1)	0.0066	0.0019	0.0113	0.0065	0.0060	0.0035
Z(2)	0.0035	-0.0042	0.0065	0.0246	0.0240	0.0263
Z(3)	0.0017	-0.0064	0.0060	0.0240	0.0296	0.0336
Z(4)	-0.0209	-0.0298	0.0035	0.0263	0.0336	0.1096

CORRELATION MATRIX:

A	1.0000	0.7573	0.2287	0.0831	0.0367	-0.2316
B	0.7573	1.0000	0.1262	-0.1906	-0.2655	-0.6429
Z(1)	0.2287	0.1262	1.0000	0.3888	0.3294	0.0989
Z(2)	0.0831	-0.1906	0.3888	1.0000	0.8887	0.5059
Z(3)	0.0367	-0.2655	0.3294	0.8887	1.0000	0.5900
Z(4)	-0.2316	-0.6429	0.0989	0.5059	0.5900	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,		UPPER BOUND)
0.005	0.5767	(0.3939	,	0.7440)
0.010	0.6274	(0.4620	,	0.7721)
0.020	0.6805	(0.5340	,	0.8031)
0.030	0.7124	(0.5769	,	0.8229)
0.040	0.7353	(0.6072	,	0.8379)
0.050	0.7533	(0.6305	,	0.8500)
0.060	0.7681	(0.6492	,	0.8603)
0.070	0.7806	(0.6649	,	0.8692)
0.080	0.7915	(0.6782	,	0.8770)
0.090	0.8011	(0.6898	,	0.8841)
0.100	0.8097	(0.7001	,	0.8905)
0.110	0.8175	(0.7092	,	0.8963)
0.120	0.8246	(0.7175	,	0.9016)
0.130	0.8312	(0.7250	,	0.9065)
0.140	0.8372	(0.7319	,	0.9111)
0.150	0.8429	(0.7383	,	0.9153)
0.200	0.8663	(0.7643	,	0.9329)
0.250	0.8844	(0.7841	,	0.9462)
0.300	0.8992	(0.8001	,	0.9565)
0.400	0.9222	(0.8256	,	0.9715)
0.500	0.9398	(0.8461	,	0.9816)
0.600	0.9542	(0.8641	,	0.9885)
0.700	0.9664	(0.8811	,	0.9934)
0.800	0.9771	(0.8985	,	0.9968)
0.900	0.9871	(0.9188	,	0.9989)
0.950	0.9923	(0.9329	,	0.9996)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0052, 0.5793)	(0.0007, 0.4434)	(0.0278, 0.7063)
(0.0436, 0.7423)	(0.0203, 0.6817)	(0.0848, 0.7963)
(0.0604, 0.7687)	(0.0315, 0.7164)	(0.1068, 0.8151)
(0.3273, 0.9061)	(0.2559, 0.8863)	(0.4056, 0.9233)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 82.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	135.	10.	0.	0.	4.
ACTUALLY POSITIVE CASES	29.	1.	1.	5.	46.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0268 0.0268 0.0268 0.0940 1.0000

TPF: 0.0000 0.5610 0.6220 0.6341 0.6463 1.0000

INITIAL VALUES OF PARAMETERS:

A= 0.7642 B= 0.2756

Z(K)= 1.3170 1.7297 1.8297 1.9297

LOGL= -142.8031

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:

A= 0.7916 B= 0.3089

Z(K)= 1.3225 1.7410 1.7930 2.0498

LOGL= -140.5911

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	0.0733	0.0328	0.0093	-0.0032	-0.0052	-0.0172
B	0.0328	0.0204	0.0023	-0.0066	-0.0080	-0.0164
Z(1)	0.0093	0.0023	0.0204	0.0171	0.0168	0.0150
Z(2)	-0.0032	-0.0066	0.0171	0.0314	0.0315	0.0327
Z(3)	-0.0052	-0.0080	0.0168	0.0315	0.0340	0.0357
Z(4)	-0.0172	-0.0164	0.0150	0.0327	0.0357	0.0536

CORRELATION MATRIX:

A	1.0000	0.8490	0.2413	-0.0675	-0.1051	-0.2742
B	0.8490	1.0000	0.1123	-0.2591	-0.3030	-0.4970
Z(1)	0.2413	0.1123	1.0000	0.6764	0.6365	0.4546
Z(2)	-0.0675	-0.2591	0.6764	1.0000	0.9640	0.7976
Z(3)	-0.1051	-0.3030	0.6365	0.9640	1.0000	0.8360
Z(4)	-0.2742	-0.4970	0.4546	0.7976	0.8360	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4983	(0.3469 ,	0.6499)
0.010	0.5290	(0.3929 ,	0.6618)
0.020	0.5624	(0.4405 ,	0.6785)
0.030	0.5833	(0.4681 ,	0.6918)
0.040	0.5989	(0.4870 ,	0.7032)
0.050	0.6115	(0.5011 ,	0.7136)
0.060	0.6222	(0.5121 ,	0.7231)
0.070	0.6314	(0.5210 ,	0.7319)
0.080	0.6396	(0.5284 ,	0.7401)
0.090	0.6470	(0.5347 ,	0.7478)
0.100	0.6538	(0.5400 ,	0.7551)
0.110	0.6601	(0.5447 ,	0.7620)
0.120	0.6659	(0.5489 ,	0.7686)
0.130	0.6713	(0.5526 ,	0.7749)
0.140	0.6765	(0.5559 ,	0.7808)
0.150	0.6813	(0.5589 ,	0.7865)
0.200	0.7025	(0.5707 ,	0.8119)
0.250	0.7202	(0.5791 ,	0.8332)
0.300	0.7356	(0.5856 ,	0.8516)

0.400	0.7622	(	0.5954	, 0.8821	)
0.500	0.7857	(	0.6029	, 0.9070	)
0.600	0.8078	(	0.6094	, 0.9281	)
0.700	0.8298	(	0.6155	, 0.9466	)
0.800	0.8535	(	0.6219	, 0.9635	)
0.900	0.8825	(	0.6298	, 0.9795	)
0.950	0.9032	(	0.6357	, 0.9879	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0202, 0.5629)	(0.0062, 0.5073)	(0.0552, 0.6173)
(0.0365, 0.5939)	(0.0156, 0.5501)	(0.0761, 0.6366)
(0.0408, 0.6001)	(0.0184, 0.5582)	(0.0817, 0.6410)
(0.0930, 0.6491)	(0.0545, 0.6165)	(0.1487, 0.6807)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 27.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	100.	14.	0.	21.	14.
ACTUALLY POSITIVE CASES	11.	1.	0.	11.	4.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0940 0.2349 0.3289 1.0000
TPF: 0.0000 0.1481 0.5556 0.5926 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.0544 B= 1.5447
Z(K)= 0.4426 0.7225 1.3170
LOGL= -180.4581
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.9177 B= 1.3982
Z(K)= 0.4487 0.6788 1.3417
LOGL= -179.8747
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:
A 0.1578 0.1213 0.0189 0.0149 -0.0004

B	0.1213	0.1589	0.0070	0.0008	-0.0213
Z(1)	0.0189	0.0070	0.0113	0.0099	0.0069
Z(2)	0.0149	0.0008	0.0099	0.0119	0.0092
Z(3)	-0.0004	-0.0213	0.0069	0.0092	0.0207

CORRELATION MATRIX:

A	1.0000	0.7660	0.4469	0.3448	-0.0065
B	0.7660	1.0000	0.1651	0.0182	-0.3724
Z(1)	0.4469	0.1651	1.0000	0.8521	0.4504
Z(2)	0.3448	0.0182	0.8521	1.0000	0.5831
Z(3)	-0.0065	-0.3724	0.4504	0.5831	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.0036	(0.0000 ,	0.1186)
0.010	0.0098	(0.0001 ,	0.1550)
0.020	0.0253	(0.0010 ,	0.2037)
0.030	0.0434	(0.0033 ,	0.2402)
0.040	0.0629	(0.0071 ,	0.2707)
0.050	0.0834	(0.0127 ,	0.2978)
0.060	0.1044	(0.0201 ,	0.3225)
0.070	0.1259	(0.0290 ,	0.3456)
0.080	0.1475	(0.0395 ,	0.3675)
0.090	0.1692	(0.0514 ,	0.3885)
0.100	0.1909	(0.0645 ,	0.4089)
0.110	0.2126	(0.0785 ,	0.4287)
0.120	0.2341	(0.0933 ,	0.4482)
0.130	0.2555	(0.1088 ,	0.4673)
0.140	0.2766	(0.1248 ,	0.4863)
0.150	0.2975	(0.1410 ,	0.5051)
0.200	0.3979	(0.2227 ,	0.5969)
0.250	0.4900	(0.2980 ,	0.6845)
0.300	0.5734	(0.3635 ,	0.7640)
0.400	0.7136	(0.4698 ,	0.8857)
0.500	0.8206	(0.5554 ,	0.9551)
0.600	0.8982	(0.6304 ,	0.9864)
0.700	0.9506	(0.7009 ,	0.9972)
0.800	0.9819	(0.7716 ,	0.9997)
0.900	0.9966	(0.8498 ,	1.0000)
0.950	0.9994	(0.8981 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0898, 0.1689)	(0.0522, 0.0881)	(0.1446, 0.2863)
(0.2486, 0.4875)	(0.1860, 0.3705)	(0.3210, 0.6056)
(0.3268, 0.6142)	(0.2554, 0.4994)	(0.4051, 0.7197)

1

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 150.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	93.	42.	9.	5.	0.
ACTUALLY POSITIVE CASES	24.	42.	37.	27.	20.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0336 0.0940 0.3758 1.0000
TPF: 0.0000 0.1333 0.3133 0.5600 0.8400 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.2702 B= 0.8959
Z(K)= 0.3160 1.3170 1.8313 2.7112
LOGL= -378.3870
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AF

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.2787 B= 0.8858
Z(K)= 0.3172 1.2914 1.9619 2.7109
LOGL= -376.3607
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AF

VARIANCE-COVARIANCE MATRIX:

A	0.0312	0.0155	0.0106	0.0052	-0.0025	-0.0137
B	0.0155	0.0171	0.0034	-0.0060	-0.0167	-0.0309
Z(1)	0.0106	0.0034	0.0109	0.0067	0.0044	0.0016
Z(2)	0.0052	-0.0060	0.0067	0.0165	0.0189	0.0234
Z(3)	-0.0025	-0.0167	0.0044	0.0189	0.0361	0.0480
Z(4)	-0.0137	-0.0309	0.0016	0.0234	0.0480	0.0866

CORRELATION MATRIX:

A	1.0000	0.6727	0.5739	0.2270	-0.0744	-0.2638
B	0.6727	1.0000	0.2506	-0.3583	-0.6697	-0.8032
Z(1)	0.5739	0.2506	1.0000	0.4988	0.2195	0.0519
Z(2)	0.2270	-0.3583	0.4988	1.0000	0.7734	0.6186
Z(3)	-0.0744	-0.6697	0.2195	0.7734	1.0000	0.8585
Z(4)	-0.2638	-0.8032	0.0519	0.6186	0.8585	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1578	(0.0665 ,	0.3070)
0.010	0.2170	(0.1098 ,	0.3680)
0.020	0.2943	(0.1759 ,	0.4400)
0.030	0.3491	(0.2280 ,	0.4880)
0.040	0.3926	(0.2717 ,	0.5251)
0.050	0.4291	(0.3095 ,	0.5556)
0.060	0.4606	(0.3431 ,	0.5818)
0.070	0.4885	(0.3731 ,	0.6048)
0.080	0.5135	(0.4004 ,	0.6255)
0.090	0.5362	(0.4253 ,	0.6443)
0.100	0.5570	(0.4482 ,	0.6616)
0.110	0.5761	(0.4694 ,	0.6775)
0.120	0.5940	(0.4891 ,	0.6924)
0.130	0.6106	(0.5075 ,	0.7064)
0.140	0.6261	(0.5247 ,	0.7195)
0.150	0.6408	(0.5408 ,	0.7319)
0.200	0.7031	(0.6090 ,	0.7852)
0.250	0.7522	(0.6622 ,	0.8275)
0.300	0.7923	(0.7055 ,	0.8619)
0.400	0.8542	(0.7729 ,	0.9132)
0.500	0.8995	(0.8245 ,	0.9479)
0.600	0.9335	(0.8665 ,	0.9710)
0.700	0.9593	(0.9024 ,	0.9858)
0.800	0.9785	(0.9342 ,	0.9945)
0.900	0.9921	(0.9638 ,	0.9988)
0.950	0.9969	(0.9790 ,	0.9997)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0034, 0.1308)	(0.0005, 0.0512)	(0.0164, 0.2704)
(0.0249, 0.3230)	(0.0098, 0.2150)	(0.0560, 0.4486)
(0.0983, 0.5536)	(0.0613, 0.4647)	(0.1493, 0.6398)
(0.3755, 0.8408)	(0.3010, 0.7929)	(0.4551, 0.8807)

1

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

DATA DESCRIPTION: [redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 59.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	38.	61.	40.	8.	2.
ACTUALLY POSITIVE CASES	2.	3.	16.	6.	32.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0134 0.0671 0.3356 0.7450 1.0000
TPF: 0.0000 0.5424 0.6441 0.9153 0.9661 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.4749 B= 0.6394
Z(K)= -0.6584 0.4241 1.4979 2.2142
LOGL= -263.4115
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.4939 B= 0.6633
Z(K)= -0.6526 0.4028 1.5744 2.1027
LOGL= -262.5013
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.0536	0.0202	0.0051	0.0058	0.0046	-0.0010
B	0.0202	0.0175	0.0020	0.0010	-0.0061	-0.0151
Z(1)	0.0051	0.0020	0.0122	0.0052	0.0026	0.0015
Z(2)	0.0058	0.0010	0.0052	0.0108	0.0064	0.0055
Z(3)	0.0046	-0.0061	0.0026	0.0064	0.0251	0.0257
Z(4)	-0.0010	-0.0151	0.0015	0.0055	0.0257	0.0492

CORRELATION MATRIX:

A	1.0000	0.6613	0.1977	0.2416	0.1252	-0.0192
B	0.6613	1.0000	0.1374	0.0691	-0.2914	-0.5166
Z(1)	0.1977	0.1374	1.0000	0.4489	0.1491	0.0602
Z(2)	0.2416	0.0691	0.4489	1.0000	0.3873	0.2376
Z(3)	0.1252	-0.2914	0.1491	0.3873	1.0000	0.7321
Z(4)	-0.0192	-0.5166	0.0602	0.2376	0.7321	1.0000

1 [redacted]

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4149	(0.2371 ,	0.6125)
0.010	0.4803	(0.3068 ,	0.6577)
0.020	0.5523	(0.3895 ,	0.7066)
0.030	0.5972	(0.4434 ,	0.7371)
0.040	0.6302	(0.4837 ,	0.7598)
0.050	0.6564	(0.5159 ,	0.7780)
0.060	0.6781	(0.5426 ,	0.7933)
0.070	0.6967	(0.5654 ,	0.8065)
0.080	0.7129	(0.5853 ,	0.8181)
0.090	0.7272	(0.6029 ,	0.8284)
0.100	0.7401	(0.6187 ,	0.8378)
0.110	0.7518	(0.6329 ,	0.8464)
0.120	0.7625	(0.6459 ,	0.8542)
0.130	0.7724	(0.6578 ,	0.8615)
0.140	0.7815	(0.6688 ,	0.8683)
0.150	0.7900	(0.6789 ,	0.8746)
0.200	0.8253	(0.7210 ,	0.9007)
0.250	0.8524	(0.7531 ,	0.9206)
0.300	0.8742	(0.7789 ,	0.9363)
0.400	0.9076	(0.8194 ,	0.9590)
0.500	0.9324	(0.8509 ,	0.9743)
0.600	0.9517	(0.8774 ,	0.9847)
0.700	0.9672	(0.9012 ,	0.9917)
0.800	0.9799	(0.9240 ,	0.9962)
0.900	0.9905	(0.9480 ,	0.9989)
0.950	0.9951	(0.9627 ,	0.9996)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0177, 0.5395)	(0.0056, 0.4250)	(0.0477, 0.6509)
(0.0577, 0.6735)	(0.0297, 0.5962)	(0.1032, 0.7440)
(0.3436, 0.8900)	(0.2720, 0.8624)	(0.4213, 0.9134)
(0.7430, 0.9730)	(0.6685, 0.9627)	(0.8077, 0.9808)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 82.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	34.	89.	21.	2.	3.
ACTUALLY POSITIVE CASES	3.	27.	12.	7.	33.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0201 0.0336 0.1745 0.7718 1.0000

TPF: 0.0000 0.4024 0.4878 0.6341 0.9634 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.1938 B= 0.7160
Z(K)= -0.7446 0.9365 1.8313 2.0514
LOGL= -270.8926
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.1283 B= 0.7053
Z(K)= -0.7614 0.9868 1.6973 1.9788
LOGL= -269.4543
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.0311	0.0109	0.0060	0.0065	0.0040	0.0022
B	0.0109	0.0120	0.0028	-0.0015	-0.0078	-0.0114
Z(1)	0.0060	0.0028	0.0129	0.0037	0.0019	0.0011
Z(2)	0.0065	-0.0015	0.0037	0.0140	0.0125	0.0125
Z(3)	0.0040	-0.0078	0.0019	0.0125	0.0273	0.0283
Z(4)	0.0022	-0.0114	0.0011	0.0125	0.0283	0.0381

CORRELATION MATRIX:

A	1.0000	0.5610	0.3014	0.3090	0.1366	0.0635
B	0.5610	1.0000	0.2234	-0.1165	-0.4327	-0.5335
Z(1)	0.3014	0.2234	1.0000	0.2754	0.1009	0.0480
Z(2)	0.3090	-0.1165	0.2754	1.0000	0.6388	0.5420
Z(3)	0.1366	-0.4327	0.1009	0.6388	1.0000	0.8771
Z(4)	0.0635	-0.5335	0.0480	0.5420	0.8771	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.2455	(0.1253 ,	0.4095)
0.010	0.3040	(0.1756 ,	0.4627)
0.020	0.3743	(0.2422 ,	0.5231)
0.030	0.4213	(0.2898 ,	0.5623)
0.040	0.4575	(0.3277 ,	0.5920)
0.050	0.4872	(0.3595 ,	0.6162)
0.060	0.5125	(0.3869 ,	0.6369)
0.070	0.5347	(0.4112 ,	0.6550)
0.080	0.5545	(0.4330 ,	0.6711)
0.090	0.5724	(0.4527 ,	0.6857)
0.100	0.5887	(0.4708 ,	0.6991)
0.110	0.6037	(0.4875 ,	0.7114)
0.120	0.6177	(0.5030 ,	0.7229)
0.130	0.6307	(0.5174 ,	0.7336)
0.140	0.6429	(0.5310 ,	0.7437)
0.150	0.6544	(0.5437 ,	0.7532)
0.200	0.7036	(0.5981 ,	0.7942)
0.250	0.7430	(0.6415 ,	0.8271)
0.300	0.7760	(0.6777 ,	0.8545)

0.400	0.8289	(	0.7362	, 0.8976	)
0.500	0.8704	(	0.7831	, 0.9297	)
0.600	0.9043	(	0.8233	, 0.9540	)
0.700	0.9329	(	0.8596	, 0.9724	)
0.800	0.9574	(	0.8944	, 0.9859	)
0.900	0.9789	(	0.9309	, 0.9951	)
0.950	0.9890	(	0.9526	, 0.9982	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0239, 0.3946)	(0.0091, 0.2956)	(0.0552, 0.5009)
(0.0448, 0.4725)	(0.0216, 0.3831)	(0.0848, 0.5633)
(0.1619, 0.6672)	(0.1114, 0.6059)	(0.2252, 0.7244)
(0.7768, 0.9521)	(0.7049, 0.9342)	(0.8375, 0.9658)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION [redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 27.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	22.	58.	19.	26.	24.
ACTUALLY POSITIVE CASES	3.	6.	3.	0.	15.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.1611 0.3356 0.4631 0.8523 1.0000
TPF: 0.0000 0.5556 0.5556 0.6667 0.8889 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.5715 B= 0.5571
Z(K)= -1.0466 0.0924 0.4241 0.9900
LOGL= -260.0469
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.5870 B= 0.5037
Z(K)= -1.0604 0.1050 0.4573 0.9660
LOGL= -259.7316
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.0526	0.0065	0.0041	0.0035	0.0036	0.0040

B	0.0065	0.0229	0.0031	0.0000	-0.0010	-0.0032
Z(1)	0.0041	0.0031	0.0159	0.0051	0.0039	0.0027
Z(2)	0.0035	0.0000	0.0051	0.0104	0.0082	0.0063
Z(3)	0.0036	-0.0010	0.0039	0.0082	0.0111	0.0086
Z(4)	0.0040	-0.0032	0.0027	0.0063	0.0086	0.0148

CORRELATION MATRIX:

A	1.0000	0.1880	0.1413	0.1485	0.1479	0.1443
B	0.1880	1.0000	0.1599	0.0013	-0.0638	-0.1762
Z(1)	0.1413	0.1599	1.0000	0.3950	0.2940	0.1776
Z(2)	0.1485	0.0013	0.3950	1.0000	0.7640	0.5067
Z(3)	0.1479	-0.0638	0.2940	0.7640	1.0000	0.6694
Z(4)	0.1443	-0.1762	0.1776	0.5067	0.6694	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.2386	(0.0642 ,	0.5396)
0.010	0.2793	(0.0911 ,	0.5652)
0.020	0.3272	(0.1285 ,	0.5940)
0.030	0.3592	(0.1568 ,	0.6128)
0.040	0.3840	(0.1802 ,	0.6272)
0.050	0.4045	(0.2006 ,	0.6391)
0.060	0.4222	(0.2187 ,	0.6495)
0.070	0.4378	(0.2352 ,	0.6586)
0.080	0.4519	(0.2504 ,	0.6670)
0.090	0.4647	(0.2645 ,	0.6746)
0.100	0.4766	(0.2776 ,	0.6817)
0.110	0.4877	(0.2901 ,	0.6884)
0.120	0.4980	(0.3018 ,	0.6947)
0.130	0.5078	(0.3130 ,	0.7008)
0.140	0.5171	(0.3236 ,	0.7065)
0.150	0.5259	(0.3338 ,	0.7120)
0.200	0.5648	(0.3790 ,	0.7371)
0.250	0.5977	(0.4173 ,	0.7592)
0.300	0.6267	(0.4506 ,	0.7794)
0.400	0.6771	(0.5072 ,	0.8162)
0.500	0.7214	(0.5547 ,	0.8500)
0.600	0.7625	(0.5968 ,	0.8817)
0.700	0.8026	(0.6363 ,	0.9120)
0.800	0.8439	(0.6763 ,	0.9411)
0.900	0.8911	(0.7230 ,	0.9695)
0.950	0.9216	(0.7558 ,	0.9838)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.1670, 0.5400)	(0.1143, 0.4922)	(0.2333, 0.5872)

(0.3237, 0.6393) (0.2533, 0.5996) (0.4011, 0.6775)
(0.4582, 0.7034) (0.3804, 0.6677) (0.5377, 0.7371)
(0.8555, 0.8689) (0.7919, 0.8405) (0.9045, 0.8936)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION [redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 150.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	27.	90.	32.	0.	0.
ACTUALLY POSITIVE CASES	7.	45.	61.	25.	12.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.2148 0.8188 1.0000
TPF: 0.0000 0.0800 0.2467 0.6533 0.9533 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.9927 B= 0.7668
Z(K)= -0.9107 0.7898 2.6112 2.7112
LOGL= -384.2195
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 7 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.9878 B= 0.6626
Z(K)= -0.9335 0.8314 2.5567 3.6335
LOGL= -347.6042
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES ARE

VARIANCE-COVARIANCE MATRIX:

A	0.0162	0.0042	0.0057	0.0058	0.0026	-0.0026
B	0.0042	0.0074	0.0031	-0.0018	-0.0188	-0.0317
Z(1)	0.0057	0.0031	0.0143	0.0038	-0.0029	-0.0079
Z(2)	0.0058	-0.0018	0.0038	0.0126	0.0148	0.0178
Z(3)	0.0026	-0.0188	-0.0029	0.0148	0.0832	0.1112
Z(4)	-0.0026	-0.0317	-0.0079	0.0178	0.1112	0.2013

CORRELATION MATRIX:

A	1.0000	0.3869	0.3724	0.4085	0.0700	-0.0449
B	0.3869	1.0000	0.2980	-0.1812	-0.7584	-0.8210
Z(1)	0.3724	0.2980	1.0000	0.2866	-0.0835	-0.1477
Z(2)	0.4085	-0.1812	0.2866	1.0000	0.4581	0.3540
Z(3)	0.0700	-0.7584	-0.0835	0.4581	1.0000	0.8593
Z(4)	-0.0449	-0.8210	-0.1477	0.3540	0.8593	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED

FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.2360	(0.1295 ,	0.3783)
0.010	0.2898	(0.1764 ,	0.4291)
0.020	0.3545	(0.2378 ,	0.4868)
0.030	0.3979	(0.2817 ,	0.5241)
0.040	0.4315	(0.3167 ,	0.5525)
0.050	0.4593	(0.3463 ,	0.5756)
0.060	0.4830	(0.3720 ,	0.5953)
0.070	0.5039	(0.3949 ,	0.6126)
0.080	0.5226	(0.4156 ,	0.6280)
0.090	0.5395	(0.4344 ,	0.6419)
0.100	0.5551	(0.4518 ,	0.6547)
0.110	0.5695	(0.4680 ,	0.6666)
0.120	0.5829	(0.4830 ,	0.6776)
0.130	0.5954	(0.4971 ,	0.6879)
0.140	0.6072	(0.5105 ,	0.6977)
0.150	0.6183	(0.5230 ,	0.7069)
0.200	0.6665	(0.5775 ,	0.7470)
0.250	0.7058	(0.6218 ,	0.7800)
0.300	0.7391	(0.6592 ,	0.8082)
0.400	0.7940	(0.7203 ,	0.8547)
0.500	0.8384	(0.7698 ,	0.8921)
0.600	0.8760	(0.8123 ,	0.9229)
0.700	0.9091	(0.8507 ,	0.9485)
0.800	0.9389	(0.8876 ,	0.9698)
0.900	0.9669	(0.9263 ,	0.9870)
0.950	0.9811	(0.9493 ,	0.9941)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0001, 0.0778)	(0.0000, 0.0226)	(0.0029, 0.2013)
(0.0053, 0.2400)	(0.0009, 0.1399)	(0.0232, 0.3701)
(0.2029, 0.6689)	(0.1466, 0.6146)	(0.2704, 0.7199)
(0.8247, 0.9459)	(0.7579, 0.9267)	(0.8785, 0.9609)

1

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 59.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	82.	51.	8.	6.	2.
ACTUALLY POSITIVE CASES	1.	8.	4.	9.	37.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0134 0.0537 0.1074 0.4497 1.0000
TPF: 0.0000 0.6271 0.7797 0.8475 0.9831 1.0000

INITIAL VALUES OF PARAMETERS:
A= 2.1865 B= 0.8676
Z(K)= 0.1262 1.2407 1.6104 2.2142
LOGL= -220.2996
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 2.1233 B= 0.8333
Z(K)= 0.1238 1.2597 1.6061 2.1666
LOGL= -220.1214
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.1270	0.0611	0.0083	0.0099	0.0041	-0.0168
B	0.0611	0.0430	0.0026	-0.0018	-0.0086	-0.0286
Z(1)	0.0083	0.0026	0.0106	0.0055	0.0046	0.0032
Z(2)	0.0099	-0.0018	0.0055	0.0180	0.0165	0.0161
Z(3)	0.0041	-0.0086	0.0046	0.0165	0.0253	0.0269
Z(4)	-0.0168	-0.0286	0.0032	0.0161	0.0269	0.0560

CORRELATION MATRIX:

A	1.0000	0.8274	0.2270	0.2065	0.0715	-0.1987
B	0.8274	1.0000	0.1239	-0.0647	-0.2618	-0.5828
Z(1)	0.2270	0.1239	1.0000	0.4000	0.2837	0.1313
Z(2)	0.2065	-0.0647	0.4000	1.0000	0.7723	0.5057
Z(3)	0.0715	-0.2618	0.2837	0.7723	1.0000	0.7138
Z(4)	-0.1987	-0.5828	0.1313	0.5057	0.7138	1.0000

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4907	(0.2628 ,	0.7217)
0.010	0.5732	(0.3620 ,	0.7648)
0.020	0.6597	(0.4772 ,	0.8107)
0.030	0.7108	(0.5483 ,	0.8389)
0.040	0.7467	(0.5986 ,	0.8596)
0.050	0.7741	(0.6367 ,	0.8759)
0.060	0.7960	(0.6669 ,	0.8894)
0.070	0.8142	(0.6916 ,	0.9008)
0.080	0.8295	(0.7122 ,	0.9106)
0.090	0.8428	(0.7298 ,	0.9192)
0.100	0.8543	(0.7450 ,	0.9267)
0.110	0.8646	(0.7583 ,	0.9334)
0.120	0.8737	(0.7701 ,	0.9393)
0.130	0.8819	(0.7806 ,	0.9446)
0.140	0.8893	(0.7901 ,	0.9494)
0.150	0.8961	(0.7987 ,	0.9537)
0.200	0.9225	(0.8325 ,	0.9699)
0.250	0.9408	(0.8566 ,	0.9802)
0.300	0.9542	(0.8751 ,	0.9869)
0.400	0.9721	(0.9026 ,	0.9943)
0.500	0.9831	(0.9229 ,	0.9976)
0.600	0.9902	(0.9392 ,	0.9991)
0.700	0.9948	(0.9532 ,	0.9997)
0.800	0.9976	(0.9660 ,	0.9999)
0.900	0.9993	(0.9785 ,	1.0000)
0.950	0.9998	(0.9856 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0151, 0.6247)	(0.0043, 0.4726)	(0.0443, 0.7594)
(0.0541, 0.7837)	(0.0275, 0.7002)	(0.0978, 0.8520)
(0.1039, 0.8585)	(0.0639, 0.8035)	(0.1595, 0.9020)
(0.4507, 0.9783)	(0.3725, 0.9680)	(0.5310, 0.9857)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAL

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 82.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	98.	39.	2.	5.	5.
ACTUALLY POSITIVE CASES	5.	7.	0.	8.	62.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0336 0.0671 0.0805 0.3423 1.0000

TPF: 0.0000 0.7561 0.8537 0.8537 0.9390 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.8145 B= 0.5476
Z(K)= 0.4058 1.4017 1.4979 1.8313
LOGL= -205.7691
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.8307 B= 0.5978
Z(K)= 0.4095 1.3735 1.4355 1.8921
LOGL= -204.5984
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	0.0774	0.0364	0.0075	0.0040	0.0032	-0.0060
B	0.0364	0.0270	0.0024	-0.0042	-0.0051	-0.0154
Z(1)	0.0075	0.0024	0.0112	0.0067	0.0065	0.0051
Z(2)	0.0040	-0.0042	0.0067	0.0202	0.0199	0.0195
Z(3)	0.0032	-0.0051	0.0065	0.0199	0.0215	0.0212
Z(4)	-0.0060	-0.0154	0.0051	0.0195	0.0212	0.0394

CORRELATION MATRIX:

A	1.0000	0.7951	0.2546	0.1018	0.0795	-0.1083
B	0.7951	1.0000	0.1361	-0.1777	-0.2116	-0.4724
Z(1)	0.2546	0.1361	1.0000	0.4468	0.4199	0.2418
Z(2)	0.1018	-0.1777	0.4468	1.0000	0.9569	0.6916
Z(3)	0.0795	-0.2116	0.4199	0.9569	1.0000	0.7298
Z(4)	-0.1083	-0.4724	0.2418	0.6916	0.7298	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.6144	(0.4107 ,	0.7902)
0.010	0.6700	(0.4929 ,	0.8153)
0.020	0.7267	(0.5796 ,	0.8425)
0.030	0.7600	(0.6305 ,	0.8598)
0.040	0.7835	(0.6658 ,	0.8728)
0.050	0.8016	(0.6924 ,	0.8833)
0.060	0.8162	(0.7135 ,	0.8923)
0.070	0.8285	(0.7307 ,	0.9000)
0.080	0.8391	(0.7452 ,	0.9069)
0.090	0.8483	(0.7576 ,	0.9131)
0.100	0.8565	(0.7683 ,	0.9186)
0.110	0.8638	(0.7778 ,	0.9237)
0.120	0.8704	(0.7862 ,	0.9283)
0.130	0.8764	(0.7937 ,	0.9326)
0.140	0.8820	(0.8005 ,	0.9365)
0.150	0.8871	(0.8067 ,	0.9402)
0.200	0.9079	(0.8313 ,	0.9551)
0.250	0.9233	(0.8491 ,	0.9658)
0.300	0.9354	(0.8630 ,	0.9739)

0.400	0.9535	(	0.8843 ,	0.9847	)
0.500	0.9664	(	0.9007 ,	0.9912	)
0.600	0.9763	(	0.9147 ,	0.9953	)
0.700	0.9840	(	0.9274 ,	0.9977	)
0.800	0.9902	(	0.9401 ,	0.9991	)
0.900	0.9953	(	0.9543 ,	0.9998	)
0.950	0.9976	(	0.9637 ,	0.9999	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0292, 0.7580)	(0.0113, 0.6798)	(0.0664, 0.8244)
(0.0756, 0.8346)	(0.0425, 0.7884)	(0.1255, 0.8738)
(0.0848, 0.8437)	(0.0493, 0.8005)	(0.1368, 0.8802)
(0.3411, 0.9436)	(0.2687, 0.9281)	(0.4199, 0.9564)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 27.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	87.	40.	6.	12.	4.
ACTUALLY POSITIVE CASES	5.	7.	1.	8.	6.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0268 0.1074 0.1477 0.4161 1.0000
TPF: 0.0000 0.2222 0.5185 0.5556 0.8148 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.1369 B= 0.9553
Z(K)= 0.2115 1.0466 1.2407 1.9297
LOGL= -203.8137
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AF

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.1181 B= 0.9444
Z(K)= 0.2135 1.0427 1.2129 1.9635
LOGL= -203.6756
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.1028	0.0501	0.0105	0.0077	0.0063	-0.0052

B	0.0501	0.0503	0.0036	-0.0028	-0.0051	-0.0218
Z(1)	0.0105	0.0036	0.0107	0.0066	0.0061	0.0040
Z(2)	0.0077	-0.0028	0.0066	0.0149	0.0140	0.0123
Z(3)	0.0063	-0.0051	0.0061	0.0140	0.0171	0.0154
Z(4)	-0.0052	-0.0218	0.0040	0.0123	0.0154	0.0438

CORRELATION MATRIX:

A	1.0000	0.6973	0.3172	0.1970	0.1497	-0.0771
B	0.6973	1.0000	0.1548	-0.1016	-0.1732	-0.4642
Z(1)	0.3172	0.1548	1.0000	0.5240	0.4478	0.1836
Z(2)	0.1970	-0.1016	0.5240	1.0000	0.8780	0.4818
Z(3)	0.1497	-0.1732	0.4478	0.8780	1.0000	0.5624
Z(4)	-0.0771	-0.4642	0.1836	0.4818	0.5624	1.0000

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.0943	(0.0161 ,	0.3129)
0.010	0.1402	(0.0346 ,	0.3663)
0.020	0.2056	(0.0709 ,	0.4306)
0.030	0.2551	(0.1050 ,	0.4746)
0.040	0.2961	(0.1368 ,	0.5094)
0.050	0.3316	(0.1664 ,	0.5388)
0.060	0.3630	(0.1940 ,	0.5645)
0.070	0.3913	(0.2197 ,	0.5876)
0.080	0.4172	(0.2439 ,	0.6087)
0.090	0.4411	(0.2665 ,	0.6281)
0.100	0.4632	(0.2878 ,	0.6462)
0.110	0.4839	(0.3078 ,	0.6632)
0.120	0.5033	(0.3268 ,	0.6793)
0.130	0.5217	(0.3447 ,	0.6944)
0.140	0.5390	(0.3616 ,	0.7088)
0.150	0.5554	(0.3777 ,	0.7225)
0.200	0.6268	(0.4474 ,	0.7821)
0.250	0.6849	(0.5036 ,	0.8299)
0.300	0.7334	(0.5506 ,	0.8685)
0.400	0.8104	(0.6265 ,	0.9245)
0.500	0.8682	(0.6878 ,	0.9596)
0.600	0.9126	(0.7410 ,	0.9807)
0.700	0.9466	(0.7901 ,	0.9922)
0.800	0.9721	(0.8384 ,	0.9977)
0.900	0.9901	(0.8907 ,	0.9997)
0.950	0.9962	(0.9231 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0248, 0.2308)	(0.0088, 0.1306)	(0.0602, 0.3636)

(0.1126, 0.4891) (0.0709, 0.3939) (0.1694, 0.5850)
(0.1485, 0.5531) (0.1000, 0.4633) (0.2108, 0.6402)
(0.4155, 0.8203) (0.3386, 0.7658) (0.4957, 0.8660)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

[redacted]

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 149. NO. OF ACTUALLY POSITIVE CASES = 150.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	43.	87.	19.	0.	0.
ACTUALLY POSITIVE CASES	2.	24.	89.	24.	11.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.1275 0.7114 1.0000
TPF: 0.0000 0.0733 0.2333 0.8267 0.9867 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.8003 B= 1.0541
Z(K)= -0.5571 1.1383 2.6112 2.7112
LOGL= -343.1591
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

PROCEDURE CONVERGES AFTER 7 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.7862 B= 0.7355
Z(K)= -0.5591 1.1430 3.4209 4.4039
LOGL= -311.2273
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

VARIANCE-COVARIANCE MATRIX:

A	0.0407	0.0213	0.0064	0.0068	-0.0468	-0.0744
B	0.0213	0.0236	0.0032	-0.0046	-0.0791	-0.1112
Z(1)	0.0064	0.0032	0.0118	0.0036	-0.0060	-0.0102
Z(2)	0.0068	-0.0046	0.0036	0.0168	0.0303	0.0364
Z(3)	-0.0468	-0.0791	-0.0060	0.0303	0.3152	0.4174
Z(4)	-0.0744	-0.1112	-0.0102	0.0364	0.4174	0.5974

CORRELATION MATRIX:

A	1.0000	0.6882	0.2914	0.2582	-0.4137	-0.4775
B	0.6882	1.0000	0.1894	-0.2296	-0.9163	-0.9358
Z(1)	0.2914	0.1894	1.0000	0.2550	-0.0979	-0.1216
Z(2)	0.2582	-0.2296	0.2550	1.0000	0.4159	0.3636
Z(3)	-0.4137	-0.9163	-0.0979	0.4159	1.0000	0.9618
Z(4)	-0.4775	-0.9358	-0.1216	0.3636	0.9618	1.0000

[redacted]

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED

FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4568	(0.2456 ,	0.6814)
0.010	0.5299	(0.3296 ,	0.7227)
0.020	0.6085	(0.4307 ,	0.7659)
0.030	0.6564	(0.4966 ,	0.7922)
0.040	0.6909	(0.5455 ,	0.8112)
0.050	0.7178	(0.5842 ,	0.8264)
0.060	0.7397	(0.6160 ,	0.8390)
0.070	0.7582	(0.6428 ,	0.8498)
0.080	0.7742	(0.6658 ,	0.8593)
0.090	0.7882	(0.6859 ,	0.8677)
0.100	0.8006	(0.7037 ,	0.8754)
0.110	0.8117	(0.7194 ,	0.8824)
0.120	0.8217	(0.7336 ,	0.8888)
0.130	0.8309	(0.7464 ,	0.8948)
0.140	0.8393	(0.7580 ,	0.9003)
0.150	0.8471	(0.7686 ,	0.9055)
0.200	0.8785	(0.8106 ,	0.9271)
0.250	0.9015	(0.8402 ,	0.9436)
0.300	0.9194	(0.8626 ,	0.9563)
0.400	0.9452	(0.8949 ,	0.9743)
0.500	0.9630	(0.9179 ,	0.9854)
0.600	0.9757	(0.9359 ,	0.9923)
0.700	0.9851	(0.9510 ,	0.9964)
0.800	0.9919	(0.9646 ,	0.9987)
0.900	0.9968	(0.9778 ,	0.9997)
0.950	0.9986	(0.9853 ,	0.9999)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0000, 0.0732)	(0.0000, 0.0051)	(0.0019, 0.3675)
(0.0003, 0.2328)	(0.0000, 0.0619)	(0.0102, 0.5317)
(0.1265, 0.8278)	(0.0812, 0.7760)	(0.1870, 0.8713)
(0.7120, 0.9860)	(0.6355, 0.9794)	(0.7799, 0.9907)

1

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

DATA DESCRIPTION: Reader 9, Mass Question

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNO

NO. OF ACTUALLY NEGATIVE CASES = 125. NO. OF ACTUALLY POSITIVE CASES = 5

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	87.	25.	13.	0.	0.
ACTUALLY POSITIVE CASES	4.	6.	10.	9.	22.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.1040 0.3040 1.0000
TPF: 0.0000 0.4314 0.6078 0.8039 0.9216 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.7240 B= 0.6484
Z(K)= 0.5125 1.2592 2.5525 2.6525
LOGL= -186.1320
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIE.

PROCEDURE CONVERGES AFTER 8 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.5837 B= 0.4840
Z(K)= 0.5062 1.3070 2.7322 3.6470
LOGL= -175.6608
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIE:

VARIANCE-COVARIANCE MATRIX:

A	0.0885	0.0335	0.0074	0.0054	-0.0349	-0.0885
B	0.0335	0.0230	0.0020	-0.0021	-0.0488	-0.0949
Z(1)	0.0074	0.0020	0.0138	0.0091	0.0041	0.0004
Z(2)	0.0054	-0.0021	0.0091	0.0226	0.0227	0.0268
Z(3)	-0.0349	-0.0488	0.0041	0.0227	0.2101	0.2978
Z(4)	-0.0885	-0.0949	0.0004	0.0268	0.2978	0.5556

CORRELATION MATRIX:

A	1.0000	0.7424	0.2112	0.1205	-0.2558	-0.3991
B	0.7424	1.0000	0.1114	-0.0941	-0.7011	-0.8390
Z(1)	0.2112	0.1114	1.0000	0.5152	0.0759	0.0042
Z(2)	0.1205	-0.0941	0.5152	1.0000	0.3294	0.2388
Z(3)	-0.2558	-0.7011	0.0759	0.3294	1.0000	0.8716
Z(4)	-0.3991	-0.8390	0.0042	0.2388	0.8716	1.0000

AREA = 0.9230 STD. DEV.(AREA) = 0.0307

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.6318	(0.4299 ,	0.8024)
0.010	0.6763	(0.4955 ,	0.8228)
0.020	0.7222	(0.5636 ,	0.8458)
0.030	0.7496	(0.6035 ,	0.8608)
0.040	0.7692	(0.6315 ,	0.8721)
0.050	0.7845	(0.6527 ,	0.8814)
0.060	0.7970	(0.6698 ,	0.8893)
0.070	0.8076	(0.6839 ,	0.8961)
0.080	0.8169	(0.6959 ,	0.9022)
0.090	0.8250	(0.7063 ,	0.9077)
0.100	0.8323	(0.7154 ,	0.9127)
0.110	0.8389	(0.7236 ,	0.9172)
0.120	0.8449	(0.7309 ,	0.9214)
0.130	0.8505	(0.7375 ,	0.9252)
0.140	0.8556	(0.7436 ,	0.9288)
0.150	0.8604	(0.7492 ,	0.9322)
0.200	0.8803	(0.7719 ,	0.9460)
0.250	0.8957	(0.7890 ,	0.9565)
0.300	0.9082	(0.8027 ,	0.9648)
0.400	0.9280	(0.8242 ,	0.9768)
0.500	0.9434	(0.8415 ,	0.9849)
0.600	0.9560	(0.8566 ,	0.9905)
0.700	0.9669	(0.8709 ,	0.9945)
0.800	0.9768	(0.8857 ,	0.9973)
0.900	0.9862	(0.9034 ,	0.9991)
0.950	0.9913	(0.9160 ,	0.9996)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0001, 0.4280)	(0.0000, 0.1871)	(0.0144, 0.7004)
(0.0031, 0.6030)	(0.0001, 0.4311)	(0.0333, 0.7568)
(0.0956, 0.8292)	(0.0546, 0.7906)	(0.1557, 0.8630)
(0.3064, 0.9097)	(0.2308, 0.8902)	(0.3912, 0.9265)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 9, MicroCalcifications

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORI

NO. OF ACTUALLY NEGATIVE CASES = 125. NO. OF ACTUALLY POSITIVE CASES = 65

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	120.	4.	0.	0.	1.
ACTUALLY POSITIVE CASES	23.	0.	2.	5.	35.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0080 0.0080 0.0080 0.0400 1.0000

TPF: 0.0000 0.5385 0.6154 0.6462 0.6462 1.0000

INITIAL VALUES OF PARAMETERS:

A= 1.3348 B= 0.4725

Z(K)= 1.7511 2.2093 2.3093 2.4093

LOGL= -98.6914

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

PROCEDURE CONVERGES AFTER 8 ITERATIONS.

FINAL VALUES OF PARAMETERS:

A= 0.8911 B= 0.2887

Z(K)= 1.7590 2.0535 2.2508 2.7339

LOGL= -94.1625

CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

VARIANCE-COVARIANCE MATRIX:

A	0.1439	0.0582	0.0187	-0.0051	-0.0258	-0.0947
B	0.0582	0.0291	0.0038	-0.0093	-0.0206	-0.0582
Z(1)	0.0187	0.0038	0.0419	0.0377	0.0351	0.0291
Z(2)	-0.0051	-0.0093	0.0377	0.0578	0.0596	0.0693
Z(3)	-0.0258	-0.0206	0.0351	0.0596	0.0815	0.1048
Z(4)	-0.0947	-0.0582	0.0291	0.0693	0.1048	0.2247

CORRELATION MATRIX:

A	1.0000	0.9004	0.2413	-0.0564	-0.2380	-0.5266
B	0.9004	1.0000	0.1084	-0.2260	-0.4226	-0.7202
Z(1)	0.2413	0.1084	1.0000	0.7662	0.6009	0.2999
Z(2)	-0.0564	-0.2260	0.7662	1.0000	0.8682	0.6084
Z(3)	-0.2380	-0.4226	0.6009	0.8682	1.0000	0.7746
Z(4)	-0.5266	-0.7202	0.2999	0.6084	0.7746	1.0000

AREA = 0.8040 STD. DEV.(AREA) = 0.0912

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.5585	(0.4096 ,	0.6995)
0.010	0.5868	(0.4516 ,	0.7123)
0.020	0.6171	(0.4897 ,	0.7330)
0.030	0.6360	(0.5087 ,	0.7498)
0.040	0.6501	(0.5204 ,	0.7642)
0.050	0.6613	(0.5284 ,	0.7767)
0.060	0.6708	(0.5341 ,	0.7877)
0.070	0.6790	(0.5384 ,	0.7976)
0.080	0.6863	(0.5418 ,	0.8066)
0.090	0.6928	(0.5446 ,	0.8148)
0.100	0.6988	(0.5468 ,	0.8224)
0.110	0.7043	(0.5486 ,	0.8294)
0.120	0.7094	(0.5501 ,	0.8358)
0.130	0.7142	(0.5515 ,	0.8419)
0.140	0.7188	(0.5526 ,	0.8476)
0.150	0.7230	(0.5535 ,	0.8529)
0.200	0.7415	(0.5567 ,	0.8756)
0.250	0.7569	(0.5584 ,	0.8936)
0.300	0.7703	(0.5592 ,	0.9083)

0.400	0.7933	(	0.5595	, 0.9314	)
0.500	0.8136	(	0.5587	, 0.9489	)
0.600	0.8325	(	0.5571	, 0.9628	)
0.700	0.8514	(	0.5549	, 0.9742	)
0.800	0.8716	(	0.5517	, 0.9837	)
0.900	0.8964	(	0.5465	, 0.9919	)
0.950	0.9140	(	0.5417	, 0.9957	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0031, 0.5405)	(0.0001, 0.4339)	(0.0355, 0.6443)
(0.0122, 0.5953)	(0.0025, 0.5317)	(0.0454, 0.6564)
(0.0200, 0.6172)	(0.0058, 0.5644)	(0.0568, 0.6679)
(0.0393, 0.6492)	(0.0154, 0.6054)	(0.0872, 0.6911)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 9, FAS/AD

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNOR

NO. OF ACTUALLY NEGATIVE CASES = 125. NO. OF ACTUALLY POSITIVE CASES = 27

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	110.	10.	4.	0.	1.
ACTUALLY POSITIVE CASES	14.	2.	2.	6.	3.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0080 0.0080 0.0400 0.1200 1.0000
TPF: 0.0000 0.1111 0.3333 0.4074 0.4815 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.9060 B= 0.7267
Z(K)= 1.1751 1.7511 2.3093 2.4093
LOGL= -104.1775
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

PROCEDURE CONVERGES AFTER 9 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.7393 B= 0.6325
Z(K)= 1.1833 1.6786 2.1371 2.9004
LOGL= -96.8623
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

VARIANCE-COVARIANCE MATRIX:
A 0.2046 0.0948 0.0185 0.0021 -0.0236 -0.1023

B	0.0948	0.0614	0.0043	-0.0083	-0.0279	-0.0864
Z(1)	0.0185	0.0043	0.0213	0.0172	0.0144	0.0097
Z(2)	0.0021	-0.0083	0.0172	0.0338	0.0328	0.0381
Z(3)	-0.0236	-0.0279	0.0144	0.0328	0.0676	0.0869
Z(4)	-0.1023	-0.0864	0.0097	0.0381	0.0869	0.2634

CORRELATION MATRIX:

A	1.0000	0.8458	0.2800	0.0251	-0.2005	-0.4407
B	0.8458	1.0000	0.1192	-0.1824	-0.4333	-0.6794
Z(1)	0.2800	0.1192	1.0000	0.6440	0.3785	0.1302
Z(2)	0.0251	-0.1824	0.6440	1.0000	0.6866	0.4042
Z(3)	-0.2005	-0.4333	0.3785	0.6866	1.0000	0.6512
Z(4)	-0.4407	-0.6794	0.1302	0.4042	0.6512	1.0000

AREA = 0.7339 **STD. DEV.(AREA) = 0.1068**

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1867	(0.0572 ,	0.4202)
0.010	0.2319	(0.0903 ,	0.4499)
0.020	0.2877	(0.1370 ,	0.4895)
0.030	0.3261	(0.1708 ,	0.5199)
0.040	0.3563	(0.1972 ,	0.5459)
0.050	0.3816	(0.2186 ,	0.5691)
0.060	0.4035	(0.2366 ,	0.5904)
0.070	0.4229	(0.2519 ,	0.6102)
0.080	0.4405	(0.2652 ,	0.6286)
0.090	0.4566	(0.2769 ,	0.6459)
0.100	0.4715	(0.2873 ,	0.6622)
0.110	0.4854	(0.2966 ,	0.6776)
0.120	0.4984	(0.3051 ,	0.6921)
0.130	0.5107	(0.3128 ,	0.7059)
0.140	0.5223	(0.3199 ,	0.7190)
0.150	0.5334	(0.3264 ,	0.7315)
0.200	0.5820	(0.3533 ,	0.7854)
0.250	0.6228	(0.3739 ,	0.8282)
0.300	0.6583	(0.3908 ,	0.8628)
0.400	0.7188	(0.4183 ,	0.9138)
0.500	0.7701	(0.4414 ,	0.9480)
0.600	0.8157	(0.4628 ,	0.9707)
0.700	0.8579	(0.4843 ,	0.9854)
0.800	0.8982	(0.5081 ,	0.9942)
0.900	0.9394	(0.5393 ,	0.9987)
0.950	0.9625	(0.5638 ,	0.9997)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0019, 0.1367)	(0.0000, 0.0417)	(0.0291, 0.3231)

(0.0163, 0.2701) (0.0041, 0.1749) (0.0518, 0.3859)
(0.0466, 0.3735) (0.0207, 0.2911) (0.0937, 0.4623)
(0.1183, 0.4963) (0.0709, 0.4247) (0.1847, 0.5681)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 9, Benign or Malignant

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNOF

NO. OF ACTUALLY NEGATIVE CASES = 125. NO. OF ACTUALLY POSITIVE CASES = 12!

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	74.	45.	6.	0.	0.
ACTUALLY POSITIVE CASES	14.	35.	54.	10.	12.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.0480 0.4080 1.0000
TPF: 0.0000 0.0960 0.1760 0.6080 0.8880 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.5928 B= 1.0021
Z(K)= 0.2323 1.6649 2.5525 2.6525
LOGL= -291.5787
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

PROCEDURE CONVERGES AFTER 6 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.3650 B= 0.6517
Z(K)= 0.2320 1.6703 3.5245 4.0979
LOGL= -276.9216
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES

VARIANCE-COVARIANCE MATRIX:

A	0.0333	0.0153	0.0090	0.0013	-0.0356	-0.0483
B	0.0153	0.0162	0.0030	-0.0129	-0.0612	-0.0759
Z(1)	0.0090	0.0030	0.0128	0.0060	-0.0025	-0.0052
Z(2)	0.0013	-0.0129	0.0060	0.0358	0.0715	0.0829
Z(3)	-0.0356	-0.0612	-0.0025	0.0715	0.2948	0.3453
Z(4)	-0.0483	-0.0759	-0.0052	0.0829	0.3453	0.4386

CORRELATION MATRIX:

A	1.0000	0.6584	0.4356	0.0388	-0.3594	-0.4000
B	0.6584	1.0000	0.2100	-0.5363	-0.8854	-0.9004
Z(1)	0.4356	0.2100	1.0000	0.2790	-0.0408	-0.0689
Z(2)	0.0388	-0.5363	0.2790	1.0000	0.6956	0.6613
Z(3)	-0.3594	-0.8854	-0.0408	0.6956	1.0000	0.9602
Z(4)	-0.4000	-0.9004	-0.0689	0.6613	0.9602	1.0000

AREA = 0.8736 STD. DEV.(AREA) = 0.0249

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED

FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.3767	(0.2113 ,	0.5690)
0.010	0.4398	(0.2780 ,	0.6125)
0.020	0.5104	(0.3595 ,	0.6599)
0.030	0.5552	(0.4139 ,	0.6898)
0.040	0.5885	(0.4553 ,	0.7122)
0.050	0.6151	(0.4887 ,	0.7303)
0.060	0.6374	(0.5168 ,	0.7456)
0.070	0.6565	(0.5410 ,	0.7590)
0.080	0.6733	(0.5621 ,	0.7709)
0.090	0.6883	(0.5809 ,	0.7817)
0.100	0.7018	(0.5978 ,	0.7915)
0.110	0.7141	(0.6130 ,	0.8006)
0.120	0.7254	(0.6270 ,	0.8090)
0.130	0.7359	(0.6397 ,	0.8170)
0.140	0.7456	(0.6515 ,	0.8244)
0.150	0.7547	(0.6625 ,	0.8314)
0.200	0.7929	(0.7075 ,	0.8615)
0.250	0.8227	(0.7415 ,	0.8855)
0.300	0.8470	(0.7687 ,	0.9053)
0.400	0.8850	(0.8107 ,	0.9357)
0.500	0.9139	(0.8431 ,	0.9575)
0.600	0.9370	(0.8703 ,	0.9733)
0.700	0.9560	(0.8947 ,	0.9847)
0.800	0.9721	(0.9182 ,	0.9925)
0.900	0.9861	(0.9433 ,	0.9976)
0.950	0.9926	(0.9589 ,	0.9991)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0000, 0.0958)	(0.0000, 0.0157)	(0.0026, 0.3228)
(0.0002, 0.1756)	(0.0000, 0.0520)	(0.0069, 0.4058)
(0.0474, 0.6089)	(0.0206, 0.5138)	(0.0969, 0.6978)
(0.4083, 0.8876)	(0.3250, 0.8575)	(0.4959, 0.9128)

ROCFIT (JUNE 1993 VERSION) :

MAXIMUM LIKELIHOOD ESTIMATION
OF A BINORMAL ROC CURVE
FROM RATING DATA

DATA DESCRIPTION: Reader 10, Mass Question

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 42.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	94.	4.	1.	0.	1.
ACTUALLY POSITIVE CASES	14.	3.	3.	4.	18.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0100 0.0100 0.0200 0.0600 1.0000
TPF: 0.0000 0.4286 0.5238 0.5952 0.6667 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.5622 B= 0.6980
Z(K)= 1.5551 2.0542 2.2268 2.3268
LOGL= -87.2521
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.4407 B= 0.6401
Z(K)= 1.5592 1.9417 2.2197 2.5170
LOGL= -84.9281
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.3827	0.1857	0.0387	-0.0155	-0.0682	-0.1359
B	0.1857	0.1039	0.0084	-0.0248	-0.0567	-0.0972
Z(1)	0.0387	0.0084	0.0400	0.0346	0.0311	0.0273
Z(2)	-0.0155	-0.0248	0.0346	0.0585	0.0639	0.0722
Z(3)	-0.0682	-0.0567	0.0311	0.0639	0.0962	0.1157
Z(4)	-0.1359	-0.0972	0.0273	0.0722	0.1157	0.1722

CORRELATION MATRIX:

A	1.0000	0.9310	0.3127	-0.1038	-0.3552	-0.5292
B	0.9310	1.0000	0.1307	-0.3180	-0.5666	-0.7266
Z(1)	0.3127	0.1307	1.0000	0.7158	0.5011	0.3296
Z(2)	-0.1038	-0.3180	0.7158	1.0000	0.8521	0.7189
Z(3)	-0.3552	-0.5666	0.5011	0.8521	1.0000	0.8989
Z(4)	-0.5292	-0.7266	0.3296	0.7189	0.8989	1.0000

AREA = 0.8875 STD. DEV.(AREA) = 0.0691

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.4174	(0.1907 ,	0.6767)
0.010	0.4806	(0.2717 ,	0.6951)
0.020	0.5500	(0.3638 ,	0.7256)
0.030	0.5935	(0.4167 ,	0.7528)
0.040	0.6254	(0.4508 ,	0.7773)
0.050	0.6508	(0.4744 ,	0.7993)
0.060	0.6719	(0.4916 ,	0.8190)
0.070	0.6900	(0.5046 ,	0.8365)
0.080	0.7058	(0.5148 ,	0.8520)
0.090	0.7198	(0.5230 ,	0.8658)
0.100	0.7324	(0.5297 ,	0.8782)
0.110	0.7439	(0.5353 ,	0.8892)
0.120	0.7544	(0.5402 ,	0.8990)
0.130	0.7641	(0.5443 ,	0.9079)
0.140	0.7731	(0.5480 ,	0.9159)
0.150	0.7815	(0.5512 ,	0.9230)
0.200	0.8165	(0.5630 ,	0.9501)
0.250	0.8435	(0.5708 ,	0.9671)
0.300	0.8655	(0.5765 ,	0.9782)
0.400	0.8995	(0.5845 ,	0.9905)
0.500	0.9252	(0.5902 ,	0.9960)
0.600	0.9455	(0.5948 ,	0.9985)
0.700	0.9621	(0.5989 ,	0.9995)
0.800	0.9761	(0.6029 ,	0.9999)
0.900	0.9881	(0.6074 ,	1.0000)
0.950	0.9937	(0.6105 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0059, 0.4323)	(0.0004, 0.2447)	(0.0442, 0.6369)
(0.0132, 0.5079)	(0.0023, 0.3559)	(0.0535, 0.6587)
(0.0261, 0.5784)	(0.0078, 0.4579)	(0.0711, 0.6919)
(0.0595, 0.6710)	(0.0255, 0.5760)	(0.1215, 0.7560)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 10, MicroCalcifications

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 51.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	91.	4.	0.	1.	4.
ACTUALLY POSITIVE CASES	18.	4.	0.	5.	24.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0400 0.0500 0.0900 1.0000

TPF: 0.0000 0.4706 0.5686 0.6471 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.7439 B= 1.0039
Z(K)= 1.3410 1.6452 1.7511
LOGL= -99.3411
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.7844 B= 1.0437
Z(K)= 1.3425 1.5801 1.7761
LOGL= -98.0825
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

VARIANCE-COVARIANCE MATRIX:

A	0.6934	0.4292	0.0497	-0.0069	-0.0612
B	0.4292	0.2914	0.0129	-0.0273	-0.0655
Z(1)	0.0497	0.0129	0.0311	0.0281	0.0258
Z(2)	-0.0069	-0.0273	0.0281	0.0370	0.0395
Z(3)	-0.0612	-0.0655	0.0258	0.0395	0.0529

CORRELATION MATRIX:

A	1.0000	0.9547	0.3385	-0.0433	-0.3193
B	0.9547	1.0000	0.1350	-0.2628	-0.5272
Z(1)	0.3385	0.1350	1.0000	0.8281	0.6350
Z(2)	-0.0433	-0.2628	0.8281	1.0000	0.8929
Z(3)	-0.3193	-0.5272	0.6350	0.8929	1.0000

AREA = 0.8915 STD. DEV.(AREA) = 0.0515

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1829	(0.0150 ,	0.6407)
0.010	0.2598	(0.0475 ,	0.6488)
0.020	0.3596	(0.1264 ,	0.6644)
0.030	0.4290	(0.2035 ,	0.6813)
0.040	0.4828	(0.2705 ,	0.7002)
0.050	0.5268	(0.3258 ,	0.7211)
0.060	0.5641	(0.3699 ,	0.7437)
0.070	0.5963	(0.4045 ,	0.7672)
0.080	0.6246	(0.4313 ,	0.7906)
0.090	0.6498	(0.4521 ,	0.8133)
0.100	0.6725	(0.4684 ,	0.8346)
0.110	0.6929	(0.4813 ,	0.8543)
0.120	0.7116	(0.4917 ,	0.8722)
0.130	0.7287	(0.5002 ,	0.8882)
0.140	0.7444	(0.5072 ,	0.9025)
0.150	0.7589	(0.5131 ,	0.9151)
0.200	0.8176	(0.5321 ,	0.9584)
0.250	0.8601	(0.5423 ,	0.9801)
0.300	0.8921	(0.5487 ,	0.9907)
0.400	0.9358	(0.5563 ,	0.9981)
0.500	0.9628	(0.5605 ,	0.9997)

0.600	0.9797	(	0.5632 ,	1.0000	)
0.700	0.9901	(	0.5650 ,	1.0000	)
0.800	0.9961	(	0.5661 ,	1.0000	)
0.900	0.9991	(	0.5665 ,	1.0000	)
0.950	0.9998	(	0.5663 ,	1.0000	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0379, 0.4724)	(0.0130, 0.2946)	(0.0926, 0.6559)
(0.0570, 0.5538)	(0.0252, 0.3981)	(0.1145, 0.7016)
(0.0897, 0.6492)	(0.0457, 0.5090)	(0.1594, 0.7716)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 10, FAS/AD

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 23.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	96.	2.	1.	1.	0.
ACTUALLY POSITIVE CASES	20.	2.	0.	0.	1.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0100 0.0200 0.0400 1.0000
TPF: 0.0000 0.0435 0.0435 0.0435 0.1304 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.0057 B= 0.6871
Z(K)= 1.7511 2.0542 2.3268 2.5762
LOGL= -34.0185
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 7 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.1095 B= 0.7126
Z(K)= 1.7463 2.1891 2.3811 2.7516
LOGL= -33.5911
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	1.2379	0.5909	0.0566	-0.0612	-0.1250	-0.2807
B	0.5909	0.3157	0.0114	-0.0532	-0.0884	-0.1745
Z(1)	0.0566	0.0114	0.0514	0.0437	0.0408	0.0356
Z(2)	-0.0612	-0.0532	0.0437	0.0968	0.0986	0.1071

Z(3)	-0.1250	-0.0884	0.0408	0.0986	0.1412	0.1559
Z(4)	-0.2807	-0.1745	0.0356	0.1071	0.1559	0.3118

CORRELATION MATRIX:

A	1.0000	0.9453	0.2243	-0.1767	-0.2989	-0.4518
B	0.9453	1.0000	0.0898	-0.3045	-0.4188	-0.5560
Z(1)	0.2243	0.0898	1.0000	0.6202	0.4794	0.2813
Z(2)	-0.1767	-0.3045	0.6202	1.0000	0.8436	0.6162
Z(3)	-0.2989	-0.4188	0.4794	0.8436	1.0000	0.7429
Z(4)	-0.4518	-0.5560	0.2813	0.6162	0.7429	1.0000

AREA = 0.5355 STD. DEV.(AREA) = 0.3512

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.0421	(0.0027 ,	0.2502)
0.010	0.0607	(0.0078 ,	0.2487)
0.020	0.0878	(0.0181 ,	0.2692)
0.030	0.1091	(0.0260 ,	0.3017)
0.040	0.1275	(0.0313 ,	0.3392)
0.050	0.1439	(0.0346 ,	0.3787)
0.060	0.1590	(0.0366 ,	0.4182)
0.070	0.1730	(0.0378 ,	0.4570)
0.080	0.1862	(0.0384 ,	0.4942)
0.090	0.1987	(0.0386 ,	0.5298)
0.100	0.2107	(0.0386 ,	0.5634)
0.110	0.2222	(0.0384 ,	0.5951)
0.120	0.2333	(0.0380 ,	0.6249)
0.130	0.2441	(0.0376 ,	0.6528)
0.140	0.2545	(0.0371 ,	0.6789)
0.150	0.2646	(0.0366 ,	0.7033)
0.200	0.3120	(0.0337 ,	0.8021)
0.250	0.3553	(0.0308 ,	0.8703)
0.300	0.3959	(0.0281 ,	0.9165)
0.400	0.4718	(0.0233 ,	0.9678)
0.500	0.5436	(0.0192 ,	0.9890)
0.600	0.6140	(0.0155 ,	0.9969)
0.700	0.6854	(0.0122 ,	0.9993)
0.800	0.7609	(0.0091 ,	0.9999)
0.900	0.8468	(0.0058 ,	1.0000)
0.950	0.9001	(0.0040 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0030, 0.0321)	(0.0001, 0.0043)	(0.0487, 0.1420)
(0.0086, 0.0562)	(0.0009, 0.0173)	(0.0500, 0.1440)
(0.0143, 0.0735)	(0.0026, 0.0297)	(0.0571, 0.1548)
(0.0404, 0.1282)	(0.0142, 0.0733)	(0.0965, 0.2066)

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R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 10, Benign or Malignant

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 100.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	91.	6.	2.	1.	0.
ACTUALLY POSITIVE CASES	37.	22.	20.	6.	15.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0100 0.0300 0.0900 1.0000
TPF: 0.0000 0.1500 0.2100 0.4100 0.6300 1.0000

INITIAL VALUES OF PARAMETERS:
A= 1.8597 B= 1.1295
Z(K)= 1.3410 1.8812 2.3268 2.5762
LOGL= -186.6256
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.6595 B= 0.9936
Z(K)= 1.3387 1.8972 2.4656 2.7230
LOGL= -186.2753
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	0.3016	0.1713	0.0444	-0.0289	-0.1175	-0.1599
B	0.1713	0.1138	0.0102	-0.0408	-0.1014	-0.1302
Z(1)	0.0444	0.0102	0.0310	0.0251	0.0193	0.0167
Z(2)	-0.0289	-0.0408	0.0251	0.0514	0.0715	0.0813
Z(3)	-0.1175	-0.1014	0.0193	0.0715	0.1364	0.1605
Z(4)	-0.1599	-0.1302	0.0167	0.0813	0.1605	0.2006

CORRELATION MATRIX:

A	1.0000	0.9249	0.4596	-0.2320	-0.5793	-0.6499
B	0.9249	1.0000	0.1723	-0.5331	-0.8142	-0.8616
Z(1)	0.4596	0.1723	1.0000	0.6282	0.2976	0.2124
Z(2)	-0.2320	-0.5331	0.6282	1.0000	0.8537	0.8011
Z(3)	-0.5793	-0.8142	0.2976	0.8537	1.0000	0.9706
Z(4)	-0.6499	-0.8616	0.2124	0.8011	0.9706	1.0000

AREA = 0.8804 STD. DEV.(AREA) = 0.0438

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,		UPPER BOUND)
0.005	0.1840	(0.0429	,	0.4670)
0.010	0.2571	(0.0914	,	0.5109)
0.020	0.3514	(0.1766	,	0.5656)
0.030	0.4169	(0.2456	,	0.6060)
0.040	0.4680	(0.3013	,	0.6405)
0.050	0.5099	(0.3465	,	0.6716)
0.060	0.5455	(0.3835	,	0.7002)
0.070	0.5765	(0.4141	,	0.7266)
0.080	0.6038	(0.4398	,	0.7511)
0.090	0.6282	(0.4616	,	0.7736)
0.100	0.6502	(0.4803	,	0.7943)
0.110	0.6703	(0.4967	,	0.8132)
0.120	0.6886	(0.5111	,	0.8305)
0.130	0.7055	(0.5240	,	0.8462)
0.140	0.7211	(0.5356	,	0.8605)
0.150	0.7356	(0.5462	,	0.8736)
0.200	0.7949	(0.5882	,	0.9228)
0.250	0.8388	(0.6195	,	0.9530)
0.300	0.8726	(0.6448	,	0.9717)
0.400	0.9205	(0.6859	,	0.9902)
0.500	0.9515	(0.7201	,	0.9969)
0.600	0.9720	(0.7511	,	0.9992)
0.700	0.9854	(0.7815	,	0.9998)
0.800	0.9937	(0.8134	,	1.0000)
0.900	0.9983	(0.8520	,	1.0000)
0.950	0.9995	(0.8792	,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0032, 0.1477)	(0.0002, 0.0275)	(0.0325, 0.4310)
(0.0068, 0.2146)	(0.0007, 0.0656)	(0.0408, 0.4716)
(0.0289, 0.4108)	(0.0096, 0.2524)	(0.0731, 0.5855)
(0.0903, 0.6291)	(0.0461, 0.4947)	(0.1602, 0.7492)

1

R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 11, Mass Question

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 42.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	76.	17.	0.	1.	6.
ACTUALLY POSITIVE CASES	13.	1.	0.	2.	26.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0600 0.0700 0.2400 1.0000
TPF: 0.0000 0.6190 0.6667 0.6905 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.6234 B= 0.1714
Z(K)= 0.7060 1.4761 1.5551
LOGL= -113.0300
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 4 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.6617 B= 0.2222
Z(K)= 0.7099 1.4142 1.5978
LOGL= -111.9829
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AI

VARIANCE-COVARIANCE MATRIX:

A	0.0626	0.0207	0.0054	-0.0002	-0.0026
B	0.0207	0.0174	0.0017	-0.0046	-0.0074
Z(1)	0.0054	0.0017	0.0189	0.0132	0.0121
Z(2)	-0.0002	-0.0046	0.0132	0.0329	0.0316
Z(3)	-0.0026	-0.0074	0.0121	0.0316	0.0415

CORRELATION MATRIX:

A	1.0000	0.6284	0.1570	-0.0048	-0.0516
B	0.6284	1.0000	0.0938	-0.1911	-0.2756
Z(1)	0.1570	0.0938	1.0000	0.5295	0.4318
Z(2)	-0.0048	-0.1911	0.5295	1.0000	0.8557
Z(3)	-0.0516	-0.2756	0.4318	0.8557	1.0000

AREA = 0.7408 STD. DEV.(AREA) = 0.0756

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND, UPPER BOUND)

0.005	0.5356	(	0.3324	, 0.7297	)
0.010	0.5575	(	0.3684	, 0.7342	)
0.020	0.5813	(	0.4066	, 0.7411	)
0.030	0.5963	(	0.4297	, 0.7468	)
0.040	0.6074	(	0.4462	, 0.7519	)
0.050	0.6164	(	0.4590	, 0.7565	)
0.060	0.6240	(	0.4694	, 0.7608	)
0.070	0.6307	(	0.4782	, 0.7649	)
0.080	0.6366	(	0.4856	, 0.7688	)
0.090	0.6420	(	0.4921	, 0.7725	)
0.100	0.6469	(	0.4979	, 0.7761	)
0.110	0.6514	(	0.5030	, 0.7796	)
0.120	0.6556	(	0.5076	, 0.7829	)
0.130	0.6596	(	0.5117	, 0.7862	)
0.140	0.6633	(	0.5155	, 0.7894	)
0.150	0.6669	(	0.5190	, 0.7925	)
0.200	0.6825	(	0.5329	, 0.8070	)
0.250	0.6956	(	0.5428	, 0.8203	)
0.300	0.7072	(	0.5503	, 0.8325	)
0.400	0.7276	(	0.5609	, 0.8549	)
0.500	0.7459	(	0.5679	, 0.8754	)
0.600	0.7636	(	0.5729	, 0.8947	)
0.700	0.7817	(	0.5765	, 0.9136	)
0.800	0.8020	(	0.5789	, 0.9329	)
0.900	0.8280	(	0.5800	, 0.9546	)
0.950	0.8478	(	0.5795	, 0.9681	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0550, 0.6204)	(0.0229, 0.5862)	(0.1154, 0.6537)
(0.0786, 0.6359)	(0.0384, 0.6058)	(0.1448, 0.6651)
(0.2389, 0.6928)	(0.1637, 0.6715)	(0.3298, 0.7136)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 11, MicroCalcifications

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMAI

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 51.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	95.	0.	0.	1.	4.
ACTUALLY POSITIVE CASES	26.	2.	0.	0.	23.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0400 0.0500 0.0500 1.0000
TPF: 0.0000 0.4510 0.4510 0.4902 1.0000

INITIAL VALUES OF PARAMETERS:

A= 1.5769 B= 0.9713
Z(K)= 1.5452 1.6452 1.7511
LOGL= -67.9594
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 5 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 1.6025 B= 0.9900
Z(K)= 1.6444 1.7102 1.7441
LOGL= -66.6294
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	4.1910	2.4630	0.0735	-0.0363	-0.0944
B	2.4630	1.4733	0.0178	-0.0482	-0.0832
Z(1)	0.0735	0.0178	0.0446	0.0434	0.0428
Z(2)	-0.0363	-0.0482	0.0434	0.0474	0.0483
Z(3)	-0.0944	-0.0832	0.0428	0.0483	0.0512

CORRELATION MATRIX:

A	1.0000	0.9912	0.1699	-0.0814	-0.2037
B	0.9912	1.0000	0.0695	-0.1825	-0.3028
Z(1)	0.1699	0.0695	1.0000	0.9449	0.8960
Z(2)	-0.0814	-0.1825	0.9449	1.0000	0.9806
Z(3)	-0.2037	-0.3028	0.8960	0.9806	1.0000

AREA = 0.8726 STD. DEV.(AREA) = 0.1617

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1716	(0.0008 ,	0.8977)
0.010	0.2416	(0.0095 ,	0.8277)
0.020	0.3332	(0.0688 ,	0.7331)
0.030	0.3975	(0.1615 ,	0.6802)
0.040	0.4478	(0.2436 ,	0.6673)
0.050	0.4895	(0.2873 ,	0.6945)
0.060	0.5251	(0.2958 ,	0.7461)
0.070	0.5561	(0.2860 ,	0.8016)
0.080	0.5836	(0.2690 ,	0.8504)
0.090	0.6083	(0.2500 ,	0.8896)
0.100	0.6306	(0.2310 ,	0.9197)
0.110	0.6510	(0.2128 ,	0.9421)
0.120	0.6697	(0.1959 ,	0.9586)
0.130	0.6870	(0.1802 ,	0.9706)
0.140	0.7030	(0.1658 ,	0.9792)
0.150	0.7178	(0.1525 ,	0.9853)
0.200	0.7792	(0.1010 ,	0.9976)
0.250	0.8251	(0.0672 ,	0.9996)
0.300	0.8608	(0.0448 ,	0.9999)
0.400	0.9118	(0.0195 ,	1.0000)
0.500	0.9455	(0.0080 ,	1.0000)
0.600	0.9681	(0.0029 ,	1.0000)
0.700	0.9831	(0.0009 ,	1.0000)
0.800	0.9926	(0.0002 ,	1.0000)

0.900	0.9980	(	0.0000	, 1.0000	)
0.950	0.9994	(	0.0000	, 1.0000	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0406, 0.4506)	(0.0143, 0.2866)	(0.0967, 0.6236)
(0.0436, 0.4639)	(0.0163, 0.3040)	(0.0996, 0.6299)
(0.0500, 0.4898)	(0.0198, 0.3316)	(0.1093, 0.6497)

1 R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 11, FAS/AD

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 23.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	73.	1.	0.	14.	12.
ACTUALLY POSITIVE CASES	13.	1.	0.	5.	4.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.1200 0.2600 0.2700 1.0000
TPF: 0.0000 0.1739 0.3913 0.4348 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.6094 B= 1.3192
Z(K)= 0.6125 0.6430 1.1751
LOGL= -106.1220
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

PROCEDURE CONVERGES AFTER 3 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.6843 B= 1.3990
Z(K)= 0.6117 0.6559 1.1707
LOGL= -105.9773
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES AR

VARIANCE-COVARIANCE MATRIX:

A	0.3212	0.2899	0.0325	0.0300	-0.0014
B	0.2899	0.3677	0.0120	0.0086	-0.0324
Z(1)	0.0325	0.0120	0.0180	0.0176	0.0132
Z(2)	0.0300	0.0086	0.0176	0.0181	0.0140
Z(3)	-0.0014	-0.0324	0.0132	0.0140	0.0263

CORRELATION MATRIX:

A	1.0000	0.8435	0.4273	0.3936	-0.0149
B	0.8435	1.0000	0.1470	0.1056	-0.3302
Z(1)	0.4273	0.1470	1.0000	0.9726	0.6091
Z(2)	0.3936	0.1056	0.9726	1.0000	0.6421
Z(3)	-0.0149	-0.3302	0.6091	0.6421	1.0000

AREA = 0.6547 **STD. DEV.(AREA) = 0.0889**

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR TRUE-POSITIVE FRACTION AT EACH SPECIFIED FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.0018	(0.0000 ,	0.2380)
0.010	0.0051	(0.0000 ,	0.2586)
0.020	0.0143	(0.0001 ,	0.2840)
0.030	0.0257	(0.0004 ,	0.3022)
0.040	0.0387	(0.0011 ,	0.3174)
0.050	0.0529	(0.0026 ,	0.3310)
0.060	0.0679	(0.0049 ,	0.3438)
0.070	0.0837	(0.0084 ,	0.3561)
0.080	0.1000	(0.0130 ,	0.3683)
0.090	0.1167	(0.0188 ,	0.3804)
0.100	0.1337	(0.0259 ,	0.3927)
0.110	0.1511	(0.0341 ,	0.4053)
0.120	0.1686	(0.0434 ,	0.4182)
0.130	0.1863	(0.0536 ,	0.4316)
0.140	0.2041	(0.0646 ,	0.4456)
0.150	0.2219	(0.0762 ,	0.4601)
0.200	0.3110	(0.1372 ,	0.5426)
0.250	0.3979	(0.1919 ,	0.6380)
0.300	0.4805	(0.2348 ,	0.7342)
0.400	0.6295	(0.2939 ,	0.8855)
0.500	0.7531	(0.3348 ,	0.9637)
0.600	0.8504	(0.3685 ,	0.9921)
0.700	0.9218	(0.4003 ,	0.9990)
0.800	0.9687	(0.4343 ,	0.9999)
0.900	0.9934	(0.4784 ,	1.0000)
0.950	0.9986	(0.5130 ,	1.0000)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.1209, 0.1702)	(0.0683, 0.0811)	(0.1968, 0.3053)
(0.2559, 0.4078)	(0.1789, 0.2735)	(0.3475, 0.5540)
(0.2704, 0.4319)	(0.1908, 0.2948)	(0.3637, 0.5779)

1

R O C F I T (JUNE 1993 VERSION) :

M A X I M U M L I K E L I H O O D E S T I M A T I O N
O F A B I N O R M A L R O C C U R V E
F R O M R A T I N G D A T A

DATA DESCRIPTION: Reader 11, Benign or Malignant

DATA COLLECTED IN 5 CATEGORIES
WITH CATEGORY 5 REPRESENTING STRONGEST EVIDENCE OF POSITIVITY (E.G., THAT ABNORMA

NO. OF ACTUALLY NEGATIVE CASES = 100. NO. OF ACTUALLY POSITIVE CASES = 100.

RESPONSE DATA:

CATEGORY	1	2	3	4	5
ACTUALLY NEGATIVE CASES	56.	31.	13.	0.	0.
ACTUALLY POSITIVE CASES	21.	38.	18.	14.	9.

OBSERVED OPERATING POINTS:
FPF: 0.0000 0.0000 0.0000 0.1300 0.4400 1.0000
TPF: 0.0000 0.0900 0.2300 0.4100 0.7900 1.0000

INITIAL VALUES OF PARAMETERS:
A= 0.8157 B= 0.7526
Z(K)= 0.1507 1.1265 2.4762 2.5762
LOGL= -270.4485
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

PROCEDURE CONVERGES AFTER 7 ITERATIONS.

FINAL VALUES OF PARAMETERS:
A= 0.8626 B= 0.7836
Z(K)= 0.1283 1.2717 2.1074 2.8588
LOGL= -249.0090
CHI-SQUARE GOODNESS OF FIT NOT CALCULATED BECAUSE SOME EXPECTED CELL FREQUENCIES A

VARIANCE-COVARIANCE MATRIX:

A	0.0316	0.0134	0.0127	0.0070	-0.0015	-0.0119
B	0.0134	0.0174	0.0044	-0.0078	-0.0229	-0.0396
Z(1)	0.0127	0.0044	0.0157	0.0086	0.0045	0.0006
Z(2)	0.0070	-0.0078	0.0086	0.0247	0.0289	0.0356
Z(3)	-0.0015	-0.0229	0.0045	0.0289	0.0647	0.0826
Z(4)	-0.0119	-0.0396	0.0006	0.0356	0.0826	0.1506

CORRELATION MATRIX:

A	1.0000	0.5699	0.5690	0.2500	-0.0329	-0.1725
B	0.5699	1.0000	0.2638	-0.3768	-0.6815	-0.7725
Z(1)	0.5690	0.2638	1.0000	0.4374	0.1427	0.0120
Z(2)	0.2500	-0.3768	0.4374	1.0000	0.7221	0.5829
Z(3)	-0.0329	-0.6815	0.1427	0.7221	1.0000	0.8373
Z(4)	-0.1725	-0.7725	0.0120	0.5829	0.8373	1.0000

AREA = 0.7514 STD. DEV.(AREA) = 0.0382

1

ESTIMATED BINORMAL ROC CURVE, WITH LOWER AND UPPER
BOUNDS ON ASYMMETRIC 95% CONFIDENCE INTERVAL FOR
TRUE-POSITIVE FRACTION AT EACH SPECIFIED
FALSE-POSITIVE FRACTION:

FPF	TPF	(LOWER BOUND,	UPPER BOUND)
0.005	0.1238	(0.0441 ,	0.2718)
0.010	0.1684	(0.0728 ,	0.3207)
0.020	0.2275	(0.1178 ,	0.3791)
0.030	0.2704	(0.1544 ,	0.4187)

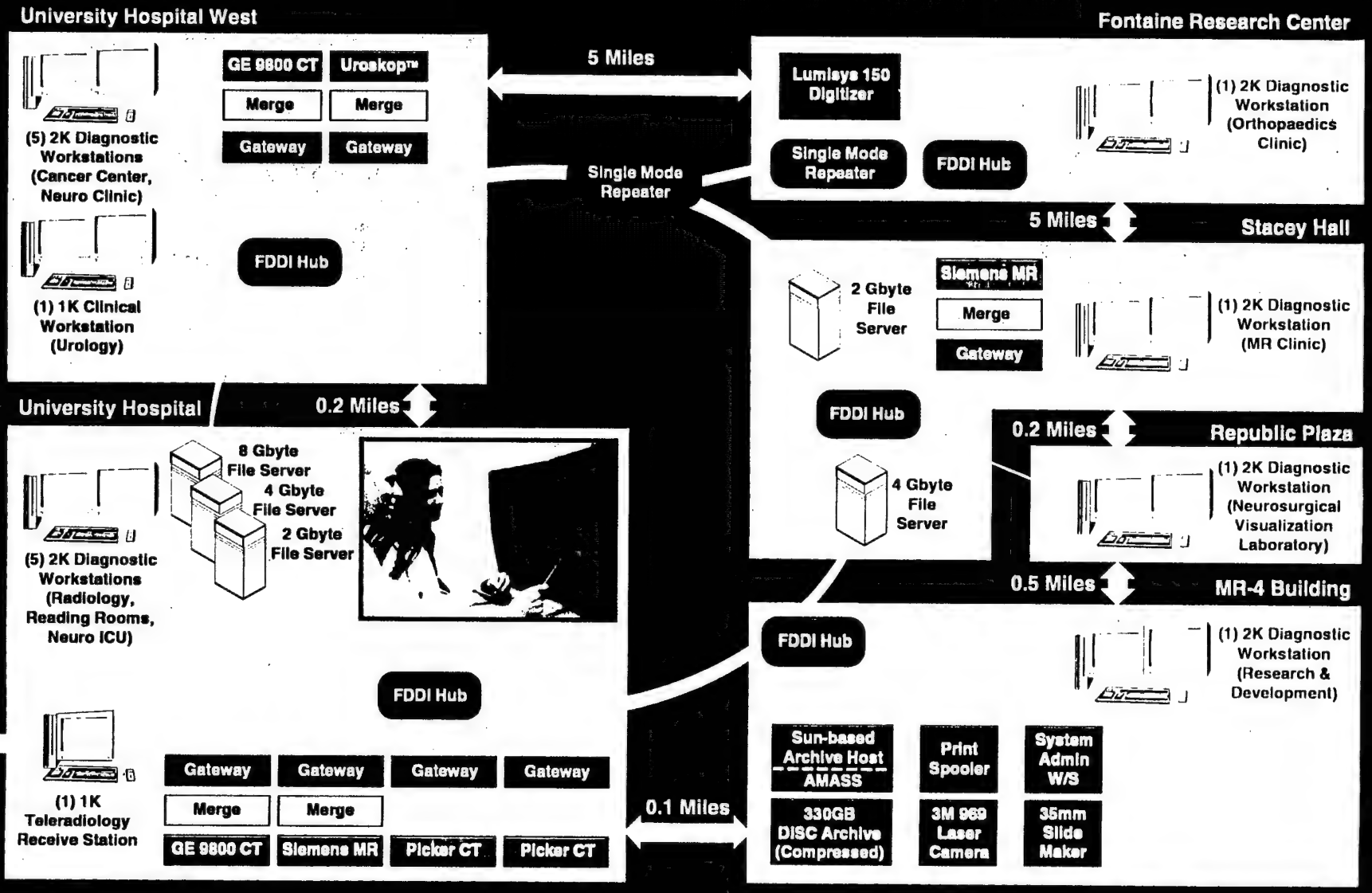
0.040	0.3052	(	0.1860	,	0.4497	)
0.050	0.3349	(	0.2142	,	0.4756	)
0.060	0.3609	(	0.2397	,	0.4982	)
0.070	0.3844	(	0.2631	,	0.5183	)
0.080	0.4057	(	0.2847	,	0.5366	)
0.090	0.4254	(	0.3048	,	0.5534	)
0.100	0.4436	(	0.3237	,	0.5690	)
0.110	0.4607	(	0.3415	,	0.5837	)
0.120	0.4768	(	0.3582	,	0.5975	)
0.130	0.4920	(	0.3741	,	0.6106	)
0.140	0.5064	(	0.3892	,	0.6230	)
0.150	0.5201	(	0.4036	,	0.6350	)
0.200	0.5805	(	0.4667	,	0.6880	)
0.250	0.6309	(	0.5188	,	0.7329	)
0.300	0.6744	(	0.5632	,	0.7719	)
0.400	0.7468	(	0.6364	,	0.8364	)
0.500	0.8058	(	0.6965	,	0.8870	)
0.600	0.8556	(	0.7491	,	0.9265	)
0.700	0.8985	(	0.7977	,	0.9566	)
0.800	0.9360	(	0.8454	,	0.9787	)
0.900	0.9690	(	0.8970	,	0.9932	)
0.950	0.9843	(	0.9286	,	0.9977	)

ESTIMATES OF EXPECTED OPERATING POINTS ON FITTED ROC CURVE, WITH LOWER AND UPPER BOUNDS OF ASYMMETRIC 95% CONFIDENCE INTERVALS ALONG THE CURVE FOR THOSE POINTS:

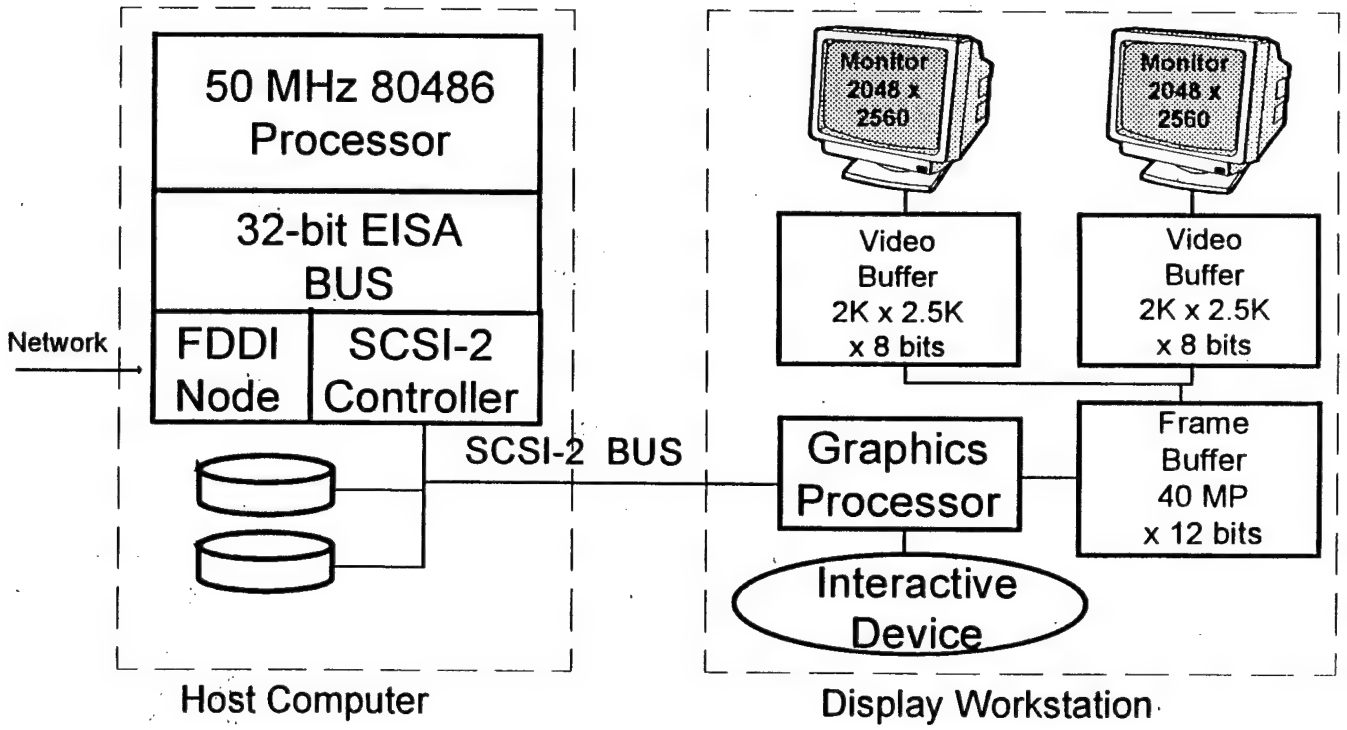
EXPECTED OPERATING POINT (FPF , TPF)	LOWER BOUND (FPF , TPF)	UPPER BOUND (FPF , TPF)
(0.0021, 0.0842)	(0.0001, 0.0242)	(0.0179, 0.2172)
(0.0175, 0.2151)	(0.0046, 0.1191)	(0.0538, 0.3453)
(0.1017, 0.4468)	(0.0571, 0.3537)	(0.1676, 0.5428)
(0.4490, 0.7770)	(0.3543, 0.7155)	(0.5467, 0.8301)

The University of Virginia PACS

EMED



DISPLAY SYSTEM



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19 March 1995

Samuel J. Dwyer III, Ph.D.
Professor
Department of Radiology
University of Virginia
MR-4 Room 1190
Charlottesville, VA 22908

Dear Sam:

Please find enclosed the findings of my visit to the Medical College of Virginia on 1/27/95 and the University of Virginia on 1/28/95 as consultant on the US Army Medical Research and Development Command grant entitled: "Evaluation of a Digital Telemammography System: a Model for a Regional System."

Visit to the Medical College of Virginia

On 1/27/95, I met with Ellen Shaw de Parades, M.D., Chief of Mammography at the Medical College of Virginia's Department of Radiology and Principal Investigator of the telemammography grant. The purpose of the consulting at the Medical College of Virginia was to analyze the design of the Receiver Operator Characteristics (ROC) studies, comment on the method of selecting images for the study, examine the images already collected for the study, and discuss strategies for analysis of the ROC after the testing has concluded. I prepared a list of questions (given below). I also sat through a few of the tests to give advice on reading room environment, e.g., view box luminance and glare.

I submitted a list of questions to Dr. de Parades regarding the analog film and digital softcopy ROC testing:

1. Has the ROC testing commenced and if so, how far along is it?
2. Has the ROC study design changed significantly from that stated in the initial proposal?
3. How are the mammograms for the ROC study selected?
4. You are selecting age-matched normal controls. Are you matching these normal mammograms for overall parenchymal density as well? If so, how are you accomplishing this?
5. Are the initial 200 mammograms cited in the grant application digitized yet? If so, what is keeping you from initiating the digital softcopy ROC portion of the study?

6. For mammogram digitization, what quality control/assurance program have you instituted?
7. In the original grant application, it was stated that the digital softcopy review might occur on any of ten different 2K resolution workstations throughout the UVA Department of Radiology. Unless these workstation's monitors are periodically and effectively calibrated, this might confound the ROC results.
8. In the original grant application, the images read at the remote Northridge outpatient clinic were to be subjected to a preference test (scale: 1-5). Would it be better to have these cases overread by mammographers at UVA and statistically calculate the analysis of variance?
9. Reading all of the analog images first produces a bias in the ROC test. It would be better to have one-half of the radiologists read the digital softcopy images first and the other radiologists read the analog images first. Of course, as there will be multiple reading sessions for each modality, each session could be randomly picked from analog or digital. This bias may, of course, be confounded as the radiologists will know which images are analog and which are digital.
10. Is ground truth available for all of the films to be used in the study? What aside information are you using to establish ground truth? Is there a truth committee? If so, who is on it and how do they arrive a conclusion regarding a case without unanimity?
11. A random number generator should also be used for ordering the analog and digital normals and abnormals in each of the ROC study sessions. Is this the case and if not, why not?
12. Who will be collecting, collating and performing the analysis of the ROC test result data? Will you be using one of the standard software packages like ROCFIT or CORROC from the University of Chicago?
13. In the grant, it is stated that in addition to the 50μm digitized radiographs, that some would be digitized at 23μm. If so, how many and are you adding this as another section of the original ROC study?
14. It appears from the grant application that the ROC results will be pooled for the four different pathology types. Is this still the case? Will you achieve sufficient statistical power in the non-pooled case?
15. How has splitting the grant across institutions (UVA and MCV) affected the design and execution of the proposed work?
16. Will you be using the BIRADS system information for patient selection? It doesn't appear that the RadCare radiology information system in place at the MCV will facilitate on-line image selection for the ROC. What system will you have to help automate patient selection?
17. Are there any problems in selecting cases from both MCV and UVA in terms of image quality differences? There should be differences in film type, screen type, mammography machine output, film processing, etc.
18. It will be possible to time the readers using the computer in the softcopy display workstation. Are you planning on doing this? If so, could the radiologist write-down the start and end times on the scoring sheets?

Advice on ROC Reading Sessions:
I also sat through three sessions of analog ROC testing with one private practice mammographer and two MCV faculty radiologists. A specific mammography view panel was used, This viewing panel had the capability of shuttering out extraneous light around the edges of the films, however, this was not done in all cases by all radiologists. Both 8"x10" and 10"x12" films were used. One row was used at a time. The medio-lateral views paired on the left, the cranial-caudal radiographs were paired on the right. The room, the mammography reading room, was fairly quiet, but was simultaneously used by another radiologist and a resident, as well as Dr. de Parades during the ROC sessions. The readers did interrupt their reading sessions to speak with colleagues or answer the phone/pager. There were no overhead lights to contend with and there was no light reflections on the ROC viewbox.

A magnifying lens was provided (will an analogous "zooming" capability be added to the softcopy display workstation as well?). A hot lamp was available (will an analogous grayscale look-up table facility be added to the softcopy display workstation as well?).

The reading sessions consist of 50 patient studies, each consisting of four radiographs (2 CC/2MLO). There is one three ring binder notebook for each reader. All of the instructions for each reader are in the notebooks, as well as all of the reader responses for each patient case read.

On the average, the magnifying glass was used in 96% of the cases read, whereas, the hot lamp was used only sparingly, about 10% of the time. The radiologists always started with the MLO views and then the CC views. Any zooming and panning would need to happen quickly to be effective (not slowing down the reading process significantly. There were several instances of the radiologists being interrupted for pages and consultations. If a timer were to be integrated into the softcopy reading workstation, a pause button would be useful.

There were several instances where films were displaced vertically to come into registration (vertical shift). This capability may need to be added to the digital review workstation. It would be very hard to be the video monitors close enough for bi-lateral comparison. Digital panning may be necessary. On the average it took two minutes and 18 seconds to read one of the 50 studies in the ROC study list.

Visit to the University of Virginia

On 1/28/95, I met with Samuel J. Dwyer, Ph.D., Director of PACS and Co-Prinicpal Investigator of the telemammography grant at the Medical College of Virginia's Department of Radiology. I also met with Beth Elias, B.S., the systems analyst for the telemammography grant. The purpose of the consulting at the University of Virginia was to examine and provide recommendations for mammogram digitization, image presentation on the viewing monitors, and image processing functionality.

I made several recommendations regarding image digitization quality control, specifically daily digitization of a standard test pattern and periodic cleaning and calibration of the digitizer. I also suggested several means of displaying the image digitally to the radiologists for that portion of the ROC testing. There were also questions regarding where an additional image reading station for the MCV portion of the digital ROC testing were coming from. It might be the case the E-systems will loan as system to the MCV for the duration of the ROC testing. Due to construction and a snow storm, it was not convenient to visit the Northridge site.

Image Digitization:
The images are being digitized at the UVA under the direction of Ms. Elias. A Lumisys digitizer, model 150, is being used for the digitization. A SMPTE (Society of Motion Picture Test Engineers) is being used for daily grayscale and resolution quality control. The mirrors of the system are cleaned bi-monthly. Every four months, a field engineer from E-systems recalibrated the digitizer densitometry.

It was suggested that the name of the patient, the patient identification number, the date of the examination and the name of the institution be masked off with electrical tape prior to digitization. It was also suggested that a single normal mammogram be used for daily grayscale quality control. This mammogram could be digitized every day, prior to digitization of mammograms for the digital part of the study. Once registered spatially, the daily mammogram could be digitally subtracted from the baseline one and the difference image studied. If it appeared that there is more than simple noise differences in the difference image, e.g., structure evident, then the densitometry might need to be adjusted more often than every four months.

Image Presentation on the Viewing Monitors:
How many monitors are going to be used for the workstations in the study? Only two. It was observed above that the radiologists reviewing the analog cases switched back and forth between the CC and MLO pairs quite often. If only two video monitors were used, this would severely hamper both the comparison necessary for diagnosis, but significantly increase the interpretation time as well. Methods were discussed with Ms. Elias for quickly context switching between the two sets (MLO and CC) of mammograms for each patient. The limiting factor here is that it is only possible to load two mammograms into the E-systems MegaScan 2K monitor digital frame buffer (32 Mbyte limit). Having to re-paint the frame buffers from magnetic disk for each MLO <-> CC context switch will most likely be interminably slow.

It was also suggested that a sequential worklist of patients for the softcopy review workstation portion of the ROC study be instituted. Currently, the radiologist has to select images from a pull-down menu list with small font. The easiest thing for the radiologists to have to do would be to push a "hot key" to advance to the next patient in the ROC study list automatically. Otherwise, with the limitations of the MLO <-> CC context switching and having to search through a complicated list of code numbers, the radiologists will become frustrated, which might impact the results of that portion of the ROC test.

Image Processing:
In order to emulate the functionality of the hot lamp and the magnifying glass, image processing functions will be implemented on the digital viewing station. However, the zooming functionality included with the E-systems MegaScan monitors looks overly complicated for a function that the radiologists used about 96% of the time in the analog portions of the ROC tests.

With regards to grayscale modifications of the digital mammograms, the user can change both the brightness and the contrast. This is accomplished fairly easily using the mouse, moving it either up or down for contrast modification and left to right for brightness/darkness changes. However, as there are three buttons on the optical mouse, a specific series of button pushes are necessary to invoke and dismiss the grayscale look-up table modification software. The radiologists are going to have to have something simple to get through the set of 50 image cases in a reasonable amount of time. I can foresee a great amount of frustration with the current user interface for zooming and look-up table modification. All but one of the mouse buttons should be disabled for the ROC testing.

Please let me know if there is anything else that you may require in this matter. It has been a pleasure working with you and Dr. de Parades on the telemammography project.

Sincerely,

Brent K. Stewart, Ph.D.
Consultant to the US Army Medical Research and Development Command Grant
Evaluation of a Digital Telemammography System: a Model for a Regional System

APPENDIX 3

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 020
Home Phone #:
DOB: 09/23/1927
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

There is an isodense, irregular mass measuring 12 millimeters with spiculated margins seen in the right breast at 2 o'clock.

Impression

Mass in the right breast is highly suggestive of malignancy. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 079
Home Phone #:
DOB: 01/01/1941
Exam Date: 08/01/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

There is an isodense, oval mass measuring 10 millimeters with circumscribed margins seen in the left breast at 12 o'clock.

Impression

Mass in the left breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 144
Home Phone #:
DOB: 01/01/1943
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There are amorphous calcifications with grouped distribution seen in the right breast at 10 o'clock.

Impression

Calcifications in the right breast are suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 143
Home Phone #:
DOB: 03/20/1938
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There is an isodense, round mass measuring 18 millimeters with indistinct margins seen in the axillary tail of the left breast.

Impression

Mass in the left breast is highly suggestive of malignancy. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 133
Home Phone #:
DOB: 10/28/1935
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There are heterogeneous calcifications with grouped distribution seen in the left breast at 6 o'clock.

Impression

Calcifications in the left breast are suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 135
Home Phone #:
DOB: 06/29/1927
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 136
Home Phone #:
DOB: 06/01/1936
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 137
Home Phone #:
DOB: 12/01/1936
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 139
Home Phone #:
DOB: 11/18/1920
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

There is an isodense, round mass measuring 5 millimeters with indistinct margins seen in the central region of the right breast.

Impression

Mass in the right breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 132
Home Phone #:
DOB: 01/01/1957
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There are amorphous calcifications with grouped distribution seen in the right breast at 10 o'clock.

Impression

Calcifications in the right breast are suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 130
Home Phone #:
DOB: 03/18/1913
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 145
Home Phone #:
DOB: 12/30/1937
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 146
Home Phone #:
DOB: 04/09/1937
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

There is a high density, round mass measuring 12 millimeters with circumscribed margins seen in the right breast at 2 o'clock.

Impression

Mass in the right breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 147
Home Phone #:
DOB: 08/02/1924
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 148
Home Phone #:
DOB: 09/10/1938
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 149
Home Phone #:
DOB: 10/24/1942
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 150
Home Phone #:
DOB: 09/21/1922
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 126
Home Phone #:
DOB: 06/17/1925
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

There is a tubular density measuring 20 millimeters seen in the subareolar region of the left breast.

Impression

Tubular density in the left breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 017
Home Phone #:
DOB: 01/01/1944
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

There is an isodense, round mass measuring 7 millimeters with circumscribed margins seen in the posterior region of the left breast at 6 o'clock.

Impression

Mass in the left breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 018
Home Phone #:
DOB: 06/18/1943
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There are amorphous calcifications with grouped distribution seen in the right breast at 12 o'clock.

Impression

Calcifications in the right breast are suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 023
Home Phone #:
DOB: 01/01/1960
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

There is an isodense, oval mass measuring 12 millimeters with obscured margins seen in the left breast at 12 o'clock.

Impression

Mass in the left breast is suspicious. Biopsy should be considered.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 049
Home Phone #:
DOB: 12/17/1915
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 016
Home Phone #:
DOB: 06/07/1944
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 016
Home Phone #:
DOB: 06/07/1944
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 048
Home Phone #:
DOB: 12/11/1922
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 042
Home Phone #:
DOB: 04/25/1934
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 001
Home Phone #:
DOB: 03/23/1949
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 010
Home Phone #:
DOB: 04/26/1934
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 038
Home Phone #:
DOB: 01/27/1948
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 034
Home Phone #:
DOB: 01/19/1939
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 009
Home Phone #:
DOB: 04/20/1921
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 046
Home Phone #:
DOB: 08/07/1943
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 015
Home Phone #:
DOB: 06/08/1942
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 047
Home Phone #:
DOB: 12/11/1912
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 026
Home Phone #:
DOB: 07/06/1917
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 043
Home Phone #:
DOB: 09/06/1945
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 002
Home Phone #:
DOB: 05/04/1944
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 044
Home Phone #:
DOB: 10/19/1934
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 025
Home Phone #:
DOB: 08/04/1920
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 035
Home Phone #:
DOB: 01/16/1945
Exam Date: 08/08/1996

Mammogram Findings

The breasts are extremely dense, which lowers the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 022
Home Phone #:
DOB: 01/27/1952
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 021
Home Phone #:
DOB: 02/02/1939
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 011
Home Phone #:
DOB: 01/01/1900
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 028
Home Phone #:
DOB: 01/01/1900
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 031
Home Phone #:
DOB: 08/01/1931
Exam Date: 08/08/1996

Mammogram Findings

The breasts are almost entirely fat.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 050
Home Phone #:
DOB: 11/12/1932
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 127
Home Phone #:
DOB: 09/23/1925
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

MCV PHYSICIANS
THE PARK AT STONY POINT

Virginia Commonwealth University

RADIOLOGY

9000 STONY POINT PARKWAY
RICHMOND, VIRGINIA 23235
804 560-8906
FAX 804 560-7345

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID: 140
Home Phone #:
DOB: 07/14/1928
Exam Date: 08/08/1996

Mammogram Findings

The breasts are heterogeneously dense. This may lower the sensitivity of mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.

MCV PHYSICIANS
THE PARK AT STONY POINT

Virginia Commonwealth University

RADIOLOGY

9000 STONY POINT PARKWAY
RICHMOND, VIRGINIA 23235
804 560-8906
FAX 804 560-7345

Consultation Report
Nelson Clinic Mammography

Paredes, M.D., Ellen
Mcv Hospitals
Radiology Box 980615
Richmond, VA 23298

Patient: Jane Doe
Patient ID:]141
Home Phone #:
DOB: 12/16/1928
Exam Date: 08/08/1996

Mammogram Findings

There are scattered fibroglandular densities that could obscure a lesion on mammography.

No masses, significant calcifications or other abnormalities are seen.

Impression

There is no mammographic evidence of malignancy.

Screening mammogram in 1 year is recommended.

Thank you for referring this patient.

E. Michelle Garris, M.D.